POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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Patent Applied for

WHY DO YOU SUPPOSE this man is examining this lily so critically through a magnifying glass? Do you suppose he is looking for bugs or dirt or is he just looking at it because he has nothing else to do?

Well, your guess is as good as ours and we don't intend to speculate upon what is passing through his mind—as a matter of fact, he is probably just posing for the photograph and the chances are, he knew all about the lily before the picture was taken.

The lily, however, is something unusual; indeed, you have never seen one like it before. For this is a "Nondehiscent" lily and if you know anything about lilies you'll have to admit that's something to write home about. As a matter of fact, the General Electric Co., when they "invented" it went right down to the patent office and applied for a patent on it.

That's a terrible name to call a nice lily, don't you think? Well, the scientists at the G. E. Research Laboratory who produced it evidently think so too for they call it the Roentgen lily or the Roentgen regal lily, after Roentgen who discovered the X-ray. For, you see, this lily was produced by the X-ray.

The term "nondehiscent" means that the anthers of the flower do not open and shed their pollen. Ordinarily, commercial growers of regal lilies must pluck the pollen-laden anthers of the flower promptly for the anthers quickly swell and burst after the flower has opened, shedding the golden pollen over the white petals and ruining the flower for display or commercial use. The new nondehiscent lily behaves differently—the anthers swell but the outer skin does not burst and as the flower ages, it gradually shrinks. All the florists are happy about it.

In the spring of 1931 C. N. Moore, of the General Electric Co. who is shown in the photograph, applied varying doses of X-rays to the bulbs of regal lilies. It is from such X-rayed bulbs that this nondehiscent lily was produced and now it is a fixed character—succeeding generations of this lily possess this characteristic permanently.

We present this remarkable development here as a feature of interest to show to what a vast variety of uses electric power is being applied. For the X-ray is an application of electric power, and whether it is used in the production of new species of plants or in testing the quality of steel in a welded boiler drum, somewhere behind the X-ray tube is an electric generator and back of the generator is a turbine or an engine or a water wheel.

It is truly amazing to note the continual expansion in the application of power to all fields of human endeavor. Consider the matter of electric welding for example. This in itself is fundamentally an electrical phenomena but in recent years it has been made distinctly more electrical by the development of remarkable electric control devices—electronic tubes, etc. In this very issue we present a new development in welding, even more electrical than other methods, i.e., high voltage condenser welding. True, it is only in the laboratory stage but it has possibilities. The use of a condenser in welding processes is not entirely new; it has been used before but its application has not been successful. With this new method, however, the difficulties seem to have been removed by the use of a specially designed transformer.

Indeed, the condenser is only recently coming into its own. For many years the electrostatic condenser was largely only a laboratory device, except in the communication field. The telephone engineer has recognized the importance of and used the condenser for many years but it is only relatively a few years since they have been applied to any extent in commercial power service. In connection with power factor improvement, the static condenser or capacitor has become of great importance. This was followed by the condenser motor and the series capacitor has been applied to transmission lines. In the conversion of a.c. to d.c., the condenser is invaluable in the filter circuit, and at M.I.T. the electrostatic generator is being investigated. The lowly Leyden Jar, it appears, is gradually coming of age and is destined to play an increasingly important part in power systems of the future.

WITH THE EDITORS

Penny Wise, Pound Foolish Policies

NOT LONG ago our attention was directed to an industrial power plant in the middle west where, despite the best effort of the operators, it was virtually impossible to obtain more than 125 per cent of rating from the boilers. This plant is comparatively new—built in 1929; in fact, it is the newest of several plants operated by the same company and, incidentally, makes the poorest showing. In itself the equipment is fundmentally correct but its efficiency has gradually become lower because of lack of proper maintenance. Stack temperatures are high because of lack of cleaning. It is a stoker fired plant but when boilers have to be cut over, grate bars have to be changed from one stoker to another because there are no new ones available. And there are a lot of other things equally absurd.

The company which owns the plant has ample money; indeed, it is operating at capacity and business is better than it has been for many years. The engineer, however, is one of those individuals who believes he can save money by spending as little as possible. His one aim is to keep the expenses in his department down, and in that respect, probably, he has made an excellent showing. But it would be appalling to know what this penny-wise, pound-foolish policy has cost the company, not only in terms of increased fuel charges but also in loss of production due to restricted power service.

Undoubtedly this is an extreme case but judging from our travels throughout the country and as the result of our visits to hundreds of power plants, it is quite evident that a considerable amount of this sort of thing exists. Operators, particularly those of the old school, are prone to make old equipment do, taking pride in their ability to point to some antiquated "museum piece" with the remark—"that there engine has been operating for thirty-five years and she runs as good as the day she was put in." Well, maybe, but the fact remains that the world has gone ahead a great deal in the last thirty-five years, and it would be well to find out how far out of date this engine is before boasting about it. As was pointed out in the October issue, the automatic control equipment at Hiram Walker plant alone was responsible for a six per cent increase in efficiency.

There is no excuse today for boiler efficiencies of 60 and 70 per cent. It may be impractical to operate at 85 per cent but certainly the modern boiler plant efficiency should not be below 78 or 80 per cent. The equipment for maintaining these values is available. If your efficiency is below this, it is time for you to look around and take notice. Investigate yourself, don't take any salesman's word for it! As an engineer you should be able to analyze conditions correctly and if you do that, you will have no reason to adhere to any penny-wise, pound-foolish policy. Highly developed, modern equipment can save money for you as well as for others. Take advantage of it by using it.

Next Year's Budget

INDUSTRIAL concerns throughout the country have developed the practice of budgeting their expenditures, so far as those expenditures can be estimated in advance, and an experienced management will set aside a reasonable sum of money for contingencies which are liable to arise. This almost universal practice has proved its value time and again in the management of business organizations in keeping a balance in the development and expenses of various departments of companies. Too often, however, the needs of the power plant serving a factory, for example, are not given the careful consideration they deserve at the hands of the budget makers.

In many such industries the power plant is considered as a necessary expense, to be held down, of course, but few directors of the budget seem to realize that in many instances the best method of reducing expenses is to invest money in power plant equipment which will pay dividends of 20 to 50 per cent in savings made possible. Right here is where the engineer in charge of the power plant should be of service to his employer, for his familiarity with the plant equipment and its operation as they are, compared with what they should be under present day practice, should enable him to make recommendations for expenditures that would be extremely profitable investments.

To secure appropriations for new equipment or a modernization construction program is a selling job and requires careful and detailed planning with compilation of costs and efficiency data dealing with every phase of the problem confronting the plant management. Recommendations for substantial appropriations must be made with extreme care, for, upon the success of the recommendations to perform as stated, the engineer banks his reputation and risks his position in the company. The task and responsibility, however, are his and cannot be shirked.

As a rule the annual budget is adopted about the beginning of the calendar year and any recommendations for unusual or out of the routine expenditures should be in the hands of the budget makers well in advance of the date of adoption. Where this is the custom, November or early December is none too early for the engineer to have his recommendations completed and ready to submit to proper officials of the company.

DURING THE early part of October the electric power output rose to the highest level on record, the production by the electric light and power industry of the United States for the week ending October 12 mounting to 1,867,127,000 kw-hr. The Edison Electric Institute gives the combined generating capacity of all steam, hydraulic and internal combustion units as 33,163,000 kw. This makes the average capacity factor on the generators in utility plants of the country approximately 33 per cent.

Fort

The Froehlich & Emery Engineering Co. of Toledo design and supervise the construction of the largest city owned plant in the state of Indiana. Efficiency and continuity of service primary considerations

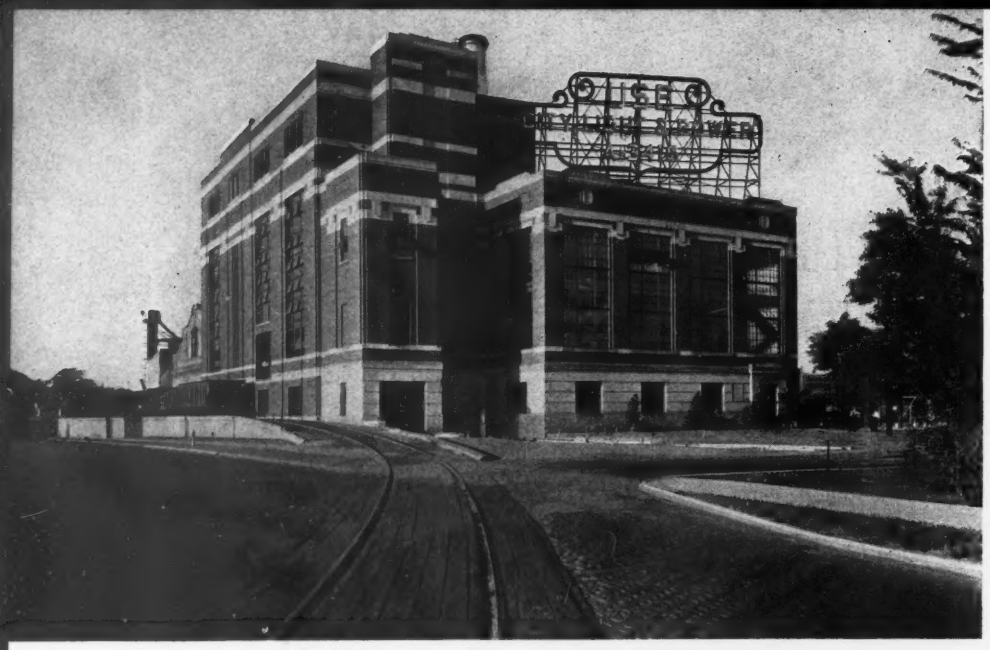

Fig. 1. Exterior view of new city light and power works

SINCE 1908 when its first municipal light plant was built, the city of Ft. Wayne, Ind., has taken an unusual interest in the development of a power and light system which is at once a source of civic pride and service to its citizens. The first plant was built from a tax fund collected for that purpose over a period of years but successive plant additions have been made from operating revenues. With additions just completed the plant now has a primary generating capacity of 22,500 kw. and a standby capacity of 10,000 kw., said to be the largest city owned plant in the state and boasts lowest domestic lighting rate in Indiana, 4 ct. per kw. hr. In addition to taking care of construction from revenues, the light department during the past four years has absorbed about $140,000 a year street, alley and public building lighting. For this excellent record of recent years, credit must be given to the designers of the plant, to the City Water and Light Department and to the superintendent of the station, Merle B. Gouty.

In 1928 it was apparent that the increasing loads demanded a comprehensive program of future development and this was entrusted to the Froehlich & Emery Eng. Co. of Toledo, O. In order that the entire development might be financed from the available building fund and earnings over succeeding years, and in order to make the greatest use of existing equipment, coal storage and condensing water facilities, etc., the plan for development contemplated the use of the same site as the existing plant, the old equipment remaining in service until replaced by the new. Accordingly, the first unit consisted of the installation of a 7500-kw. turbo-generator and auxiliary equipment, a complete new station switchboard and accompanying switchgear, all housed in a new building designed to accommodate an additional turbo-generator and future extensions to the switchboard and switchgear. To permit the construction of the first unit, two obsolete 500-kw. vertical turbo-generators were removed.

The second unit in the development consisted of a complete boiler plant, with three 931-hp. high pressure, stoker fired boilers and auxiliary equipment housed in a new building, adjoining the new turbine building, and conforming with that building in architectural design. In order to maintain the power plant in operation during the construction of the new boiler plant, it was necessary to divide the work into two parts. Upon the removal of one old 725-hp. boiler and a radial brick chimney and the construction of steel stacks for two old boilers, space was available for the installation of one new boiler and the new feedwater heating, treating and pumping equipment. With the completion of the new boiler and feedwater equipment they were operated in conjunction with four of the old boilers. A second old 725-hp. boiler and its radial brick chimney were removed and space was then available for the completion of the second part of the building and the installation of the second and third new boilers.

The third major step was the installation of a 15,000-kw. turbo-generator. Space in the new turbine building was available, after the removal of an obsolete 1500-kw. vertical steam turbo-generator. The installation of the 15,000-kw. unit was recently completed, minor changes made in the 7500-kw. unit to make it suitable for the higher steam pressure and the steam pressure raised to 400 lb. Entirely separate from the high pressure plant, except for feedwater heating and treating and for electrical connections, there remain ready for operation at 200 lb. pressure, four boilers and three turbo-generators, one 4000 kw. and two 3000 kw. These units will constitute a complete low pressure plant, to serve for reserve or standy service. The two steam systems are tied together with a Swartwout desuperheater and pressure reducing valve so that the low pressure turbines can be carried by the new boilers.

Turbine Room and Switchbay

The turbine room building, the first unit of the program, is approximately 59 ft. wide, 84 ft. long and 69 ft. high, and the switchbay, immediately adjoining, is approximately 38 ft. wide, 80 ft. long and 63 ft. high. These buildings are entirely fireproof in construction, with steel frames, brick walls with Indiana

Wayne Completes New Power Plant

limestone trim, steel sash, insulated concrete roof deck, and concrete floors and foundations. Interior wall faces are of salt glazed brick and the turbine floor is finished with red quarry tile. A 25-t. motor operated overhead traveling crane is provided for use in the erection and maintenance of the equipment.

The first turbo-generator installed, a General Electric unit, is rated at 9375 kv-a., 7500 kw. at 0.8 power factor, 3600 r.p.m. and generates three phase, sixty cycle energy at 13,800 v. Generator cooling is accomplished with a General Electric surface type air cooler, in a closed air circuit and supplied with water from the main circulating pump. Steam for feedwater heating is extracted from this turbine at the 6 and 11 stages. The 9890 sq. ft. Ingersoll-Rand surface condenser has an external air cooler and Ingersoll-Rand auxiliaries. The 11,000 g.p.m. circulating pump is dual driven, the G. E. 100-hp. motor and G. E. 83-hp. geared turbine drives being arranged with Fast cut-out type couplings. Air is removed with twin, two-stage, steam jet ejectors, with a combination inter-and after-condenser. Two two-stage condensate pumps are provided, one driven by a G. E. 20-hp. motor and one by a G. E. 20-hp. steam turbine, the hotwell level being maintained constant by a Fisher float control. Other auxiliaries consist of a Bowser continuous oil filter, duplicate Andale oil coolers and a Cochrane multiport atmospheric relief valve.

The second turbo-generator, also a General Electric, is rated at 3600 r.p.m., 15,000 kw. at 0.8 power factor, and generates three phase, sixty cycle energy at 13,800 v. Generator cooling is accomplished in the same manner as for the 7500 kw. unit. The turbine is designed for three-stage extraction for feedwater heating. Four openings are provided, however, to efficiently supply steam at the various loadings, these openings being made at the 8, 10, 13 and 15 stages.

For this turbine, a Westinghouse 14,000 sq. ft. condenser with a welded steel shell was provided. The Westinghouse circulating pump is dual driven, with a two-speed 125/60 hp. G. E. motor and a Westinghouse, 65-hp. geared turbine connected with Fast, cut-out type couplings. At the lower motor speed, the circulating pump will deliver 9500 g.p.m. against the system head. This is sufficient to maintain a vacuum of 28 in. with full load and an inlet water temperature of 60 deg. F., or to maintain the same vacuum with approximately 11,000 kw. load and an inlet water temperature of 75 deg. F. The speed regulating governor of the turbine drive is so arranged to enable the turbine to take the load automatically in the event the pump speed drops to 5 per cent below the lower motor speed and is then adjustable manually through a range equivalent to 15 per cent of normal speed. Air is removed with Westinghouse twin two-stage steam jet vacuum pumps, with a combination inter- and after-condenser. Two Westinghouse two-stage condensate pumps are provided, one driven by a G. E. 25-hp. motor and one by a G. E., 25-hp. steam turbine. Due to space limitations this unit was provided with two 18-in. atmospheric relief valves in parallel. The turbine is protected against reversed flow through the bleeder lines by Atwood-Morrill oil operated non-return valves.

Condensing water is obtained from two sources, the St. Mary's River and Spy Run. A storage pond or reservoir is located adjacent to the plant, and water from the St. Mary's River is pumped into this pond from a low lift pump house and intake located at the river. Spy Run is dammed and its water flows by gravity through a gated intake directly in to the pond. The circulating water discharge lines empty into Spy

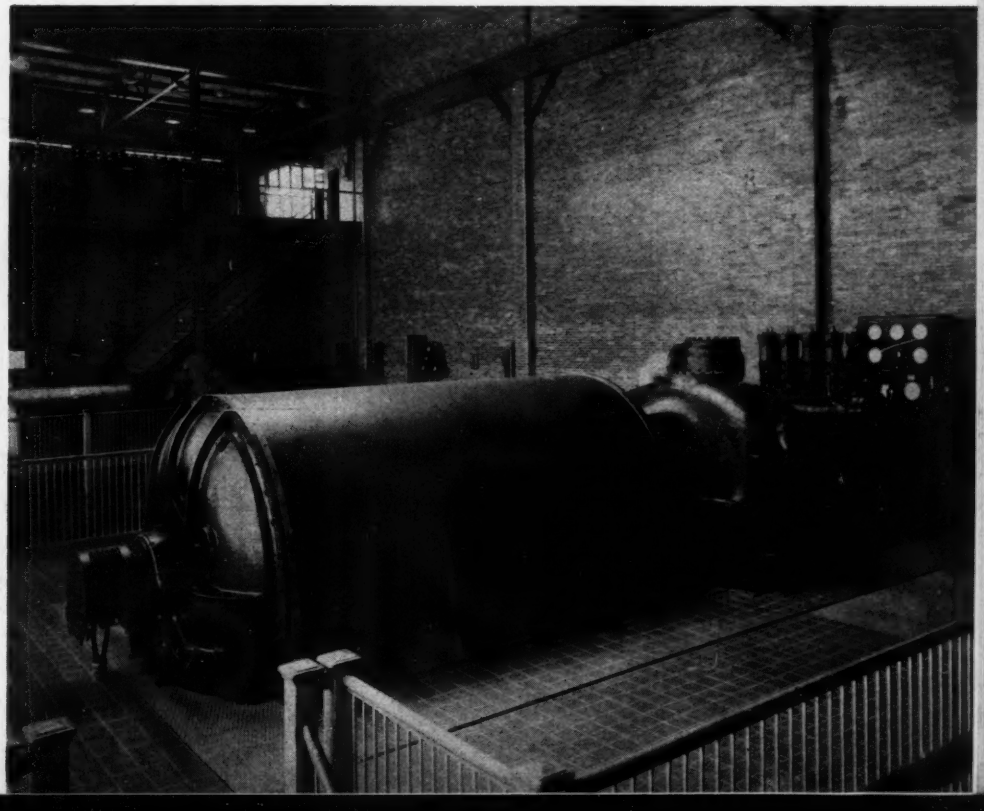

Fig. 2. Turbine room with the 15,000-kw. unit in the foreground and the 7500-kw. unit and switchboard in the background

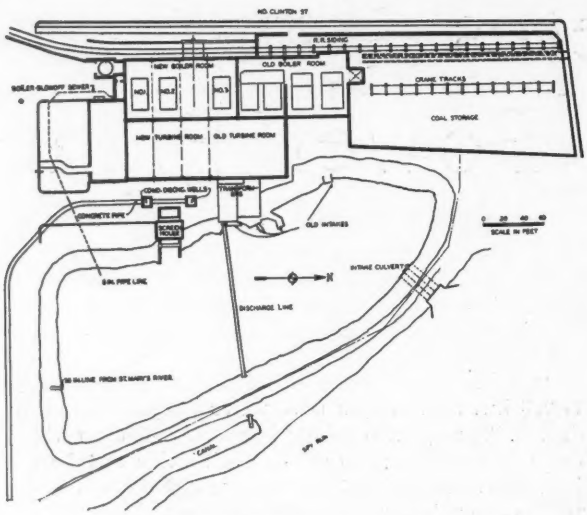

Fig. 3. Property plot showing the arrangement of the station, coal storage yard and cooling water supply

Run at a considerable distance below the intake and, at certain seasons of the year, a portion of the condenser water is recirculated, cooling in the basin formed by the dam. Water from the pond passes into the circulating pump suction well through two Link Belt traveling water screens and is treated in the suction well with Wallace & Tiernan chlorinating equipment to prevent slime.

The boiler plant building is approximately 59 ft. wide, 140 ft. long and 91 ft. high, including a 21 ft. basement. This building conforms, in architectural design, to the turbine building and is entirely fireproof in construction, with steel frame, brick walls with Indiana limestone trim, steel sash, insulated concrete roof deck, and concrete floors and foundations. Interior wall faces are of salt glazed brick and the firing aisle is finished with red quarry tile. A separate room, located in the upper part of the house, is provided for the forced and induced draft fans and a central bay of the building is arranged for the housing of the auxiliary equipment. An Otis combination passenger and service elevator, push button controlled, is provided for ready access to the various floors and galleries and to the power plant offices.

Each of the three boilers is of the B. & W. Stirling type, rated at 931 b.hp. and designed for 425 lb. W.S.P. and is equipped with a convection superheater designed to deliver steam at 700 deg. F. The bridge wall and side walls are water cooled, with Bailey vertical tube and block covered walls, making a total area of 382 sq. ft. Boilers are set with the center line of the mud drums at 12 ft. above the firing floor, the furnace width is 13 ft. and furnace volume of each boiler is 3730 cu. ft. Drum seams are fusion welded and supporting steel is continuous to the basement floor. The first row of boiler tubes is arranged to form a slag screen. Air heaters are of the B. & W. vertical tubular type, with a heating surface of 5182 sq. ft. and are designed to deliver the air at 300 deg. F.

A total of 9 Diamond soot blower units are provided for each boiler with its air heater. These complete units have been designed for satisfactory operation at all ratings from 100 to 300 per cent. Boilers have Yarway water columns and blowoff valves, Consolidated-Ashcroft-Hancock safety valves and power control valve. Sumps are drained by Yeomans vertical sump pumps and the building is heated by New York unit heaters. Squires and Anderson traps are used throughout the plant.

Stokers are of the Taylor underfeed double roll clinker grinder type, seven retorts wide and thirty-three tuyeres in length, each with a projected grate area of 187.6 sq. ft. Stoker drive is through Hele-Shaw variable speed hydraulic transmission, operated by a Starr, 15 hp. constant speed motor. Grinders are driven with four-speed motors and the ashes are discharged into Allen-Sherman-Hoff refractory lined cast iron ash hoppers, with oil operated, water collecting gates.

Due to existing track locations and property lines it was necessary to build the boiler room narrow and

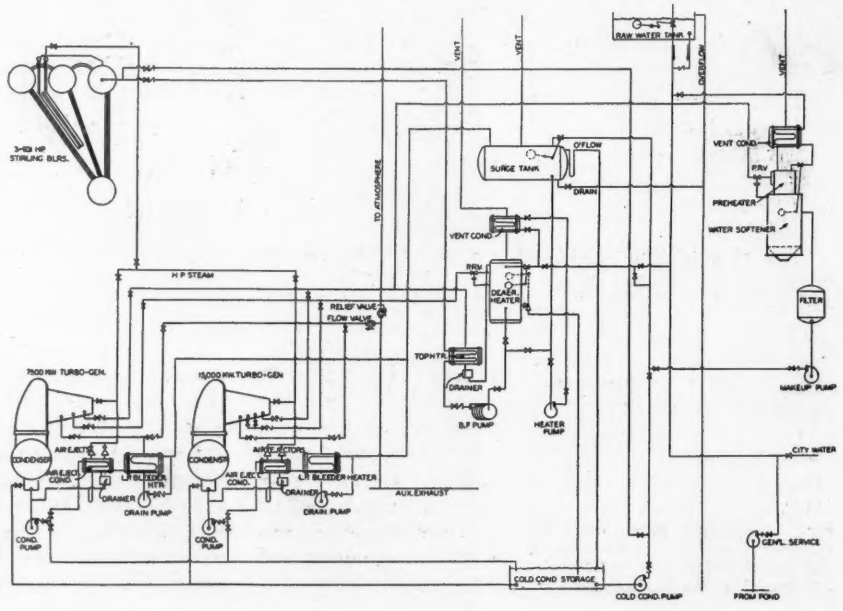

Fig. 4. Flow diagram of the station

locate both the forced and induced draft fans above the boilers in a separate fan room. Individual fans are provided for each boiler. Each forced draft fan is of the Sturtevant high speed, multiple float type, with backward curved floats, and with capacity of 37,500 c.f.m. against a static pressure of 9 in. of water. Direct connected to each fan is a G. E. 75 hp. adjustable-varying-speed, slip ring motor, with a 13 position, pilot motor operated drum controller. Each induced draft fan is of the Green high speed multiple vane type with radially curved vanes and a capacity of 70,000 c.f.m. of flue gas, at a temperature of 550 deg. F. and at a static pressure of 7 in. of water. The induced draft fan drive is a G. E. 150/85 hp. direct connected, two-speed, two-winding, squirrel cage motor controlled by two solenoid operated oil circuit breakers with electrical interlock. Duplicate busways are provided and all switchgear is installed in G. E. steel cubicles.

As the power plant is located adjacent to residential districts, Green cinder traps are installed between the gas outlets of the boilers and the inlets of the induced draft fans, to prevent the dissemination of cinders, soot and fly ash in the neighborhood. Self supporting stub steel stacks are mounted directly on the steel roof framing, and connected to the fan outlets with expansion joints.

The high pressure steam piping of the plant is constructed of seamless steel tubing, using Van Stone type joints, with phonograph finish on the face of the laps. Circulating water piping is of Class B cast iron. Other low pressure water lines are of wrought iron, as are the trap discharge line. Low pressure steam and exhaust lines are constructed of lap welded steel pipe. Shop welding of the pipe was used to eliminate all possible joints. Practically all gate and globe valves are of the Crane Co. manufacture.

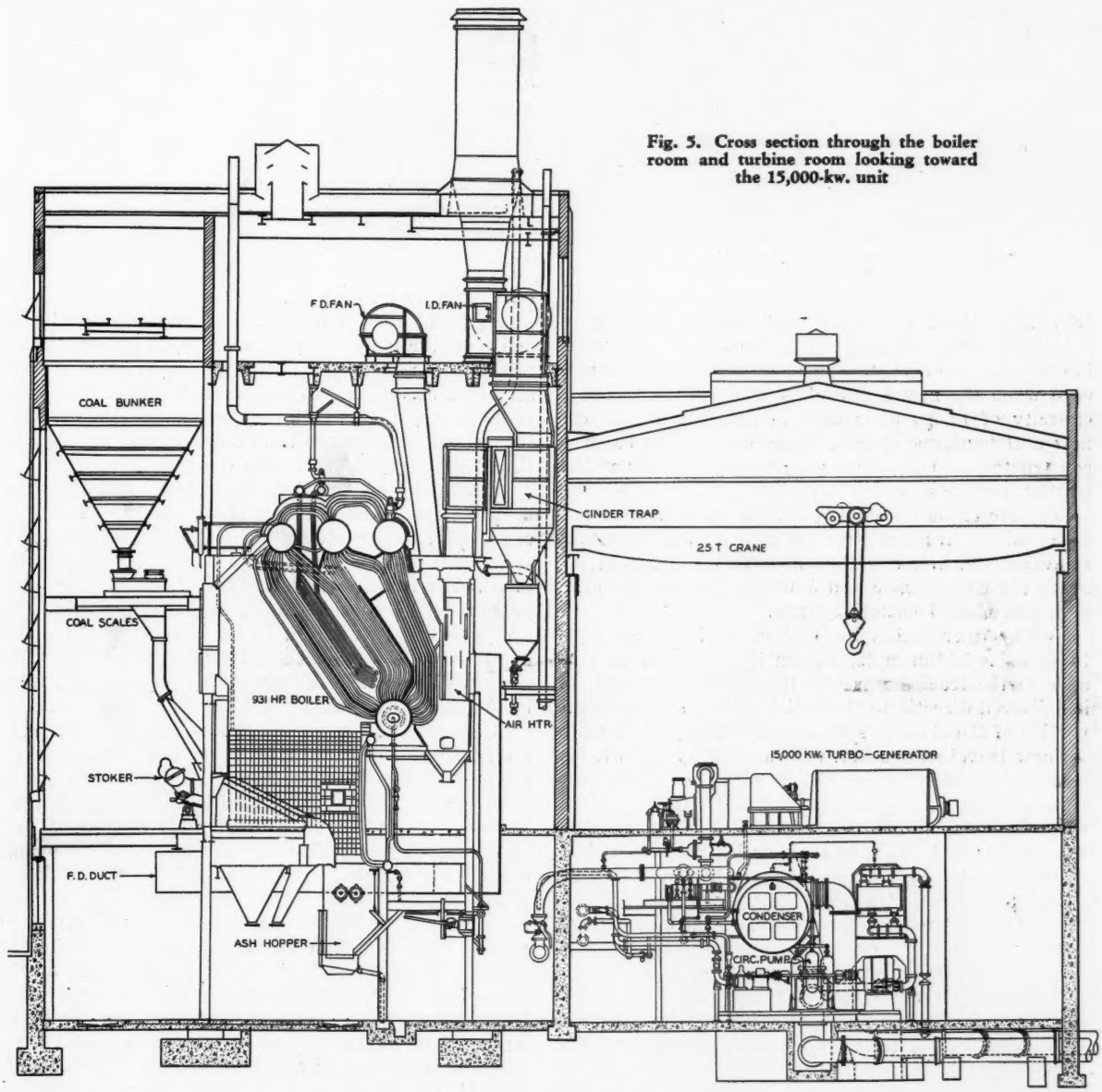

Fig. 5. Cross section through the boiler room and turbine room looking toward the 15,000-kw. unit

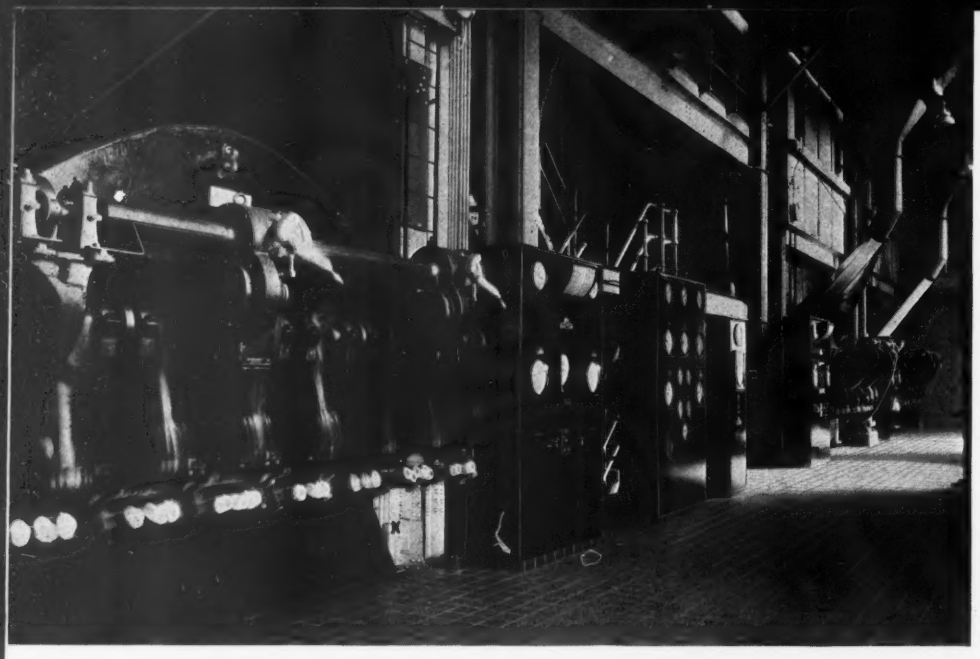

Fig. 6. The boiler room. Auxiliaries are located in a bay between the first and second boilers

Coal is delivered to the plant over a siding of the New York Central Railroad and elevated directly to individual overhead bunkers at the boilers or placed in storage. The coal storage basin, which was in existence when the new boiler plant was built, and has a capacity of 12,000 t., is used in connection with the new coal handling system. This coal storage basin is constructed of reinforced concrete with two parallel trestles, on one of which is operated an Orton electric locomotive crane with a 1¼ cu. yd. bucket. Coal can be reclaimed from storage by means of a Columbus Conveyor Co. belt conveyor operated in a tunnel beneath the coal storage and a vertical bucket elevator, or means of the locomotive crane.

With either reclaiming system, coal is discharged to an Atlas 10-ton motor driven larry car for conveyance to the track hopper of the new boiler plant, or is delivered directly to the coal handling system of the portion of the old boiler plant that remains. A Bartlett & Snow traveling crusher, with a capacity of 65 t. per hour and operated in connection with the electric locomotive crane, is provided at the coal storage for use when it is found necessary or desirable to purchase run-of-mine coal. Each of the new boilers is served by an individual 130-t. overhead, hopper bottomed bunker, with gunite lining. Coal, which has been dumped from the railroad cars or the larry car, into the double track hopper, is elevated to the bunkers by a Webster coal handling system consisting of an apron feeder and a gravity discharge elevator and belt distributor. The apron feeders and the gravity discharge elevators are installed in duplicate, and each has a capacity of 50 t. per hr. Lateral distribution from the gravity discharge elevators is effected by means of a 20 in. shuttle belt conveyor, designed to permit ready extension in the future when additional boilers are installed. Coal flows from each bunker to the stoker hopper through a Richardson dustproof, apron feed, automatic batch scale and a Roland Gardner non-segregating spreader. The coal bunkers, bucket elevators and coal feeder are enclosed in dustproof compartments.

Ashes are dumped from the boiler ash hoppers into a hand propelled industrial car and elevated by means of a Beaumont skip hoist into a steel bunker, arranged for discharge into trucks.

Soot and cinders from the last pass of each boiler and from the cinder traps are conveyed pneumatically to the ash bunker by a United Conveyor system operated by a Nash motor driven vacuum pump. The same pneumatic system is used for conveying stoker siftings to the coal bunkers and has been extended throughout the plant for general vacuum cleaning service.

Practically all auxiliary equipment, such as boiler feed pumps, deaerating heater, makeup softening equipment, condensate storage and house service water storage, is located in a central bay of the new boiler plant. For the new boilers, three Ingersoll-Rand 500 g.p.m. at 1300 ft. head centrifugal boiler feed pumps are provided, two driven by G. E. 250-hp. motor and one by a G. E. 250-hp. steam turbine. In addition, two centrifugal boiler feed pumps were relocated in the basement of the auxiliary bay to serve the old boilers.

Condensate from the hot well pumps is delivered to a steel storage or surge tank, from which it is pumped by one of two duplicate Ingersoll-Rand 500 g.p.m. pumps under Fisher float control to a Cochrane deaerating feed water heater. Considerable storage is provided in the deaerating heater and the feed pumps obtain their supply directly from this heater. Make-up is introduced into the surge tank under float control, having been previously treated in a Cochrane hot process lime and soda water softener. The softening plant is arranged with the sedimentation tank on the firing floor, with the filter, pumps and chemical tanks in the basement for ready accessibility from the chemical storage rooms. A reserve storage of condensate and treated makeup is provided by a concrete reservoir beneath the boiler room basement floor, from which the water is delivered, when required, to the surge tank or to a boiler to be filled, by one of two duplicate Yeomans motor driven vertical pumps, each with a capacity of 250 g.p.m. In addition to the treating of makeup water, the feedwater is given a final conditioning by the Hall Laboratories system of introducing phosphate into the suction line of the boiler feed pumps. The new boilers are provided with a Cochrane continuous blow-off equipment.

Since the completion of the installation of the

15,000 kw. turbo-generator and the closed feed water heaters, all heating of feed water, including that in the deaerating heater, is done, normally, with steam extracted from the main units. The piping to the deaerating heater and the closed heater, located in the circuit between the feed pumps and the boilers, is arranged so as to use extracted steam from either turbo-generator. The deaerating heater is supplied through a Brooke controller which maintains the pressure at 8 lb. gage. Exhaust steam from mechanical drive turbines is delivered to the low pressure closed heaters.

House service water is obtained from the condensing water pond, with two Ingersoll-Rand 500 g.p.m. house service pumps, one with a G. E. 20 hp. motor and the other with a G. E. 20 hp. steam turbine. An elevated storage, under automatic control, is provided as a reservoir and is normally filled by city water.

Boiler Control System

Bailey electrically operated automatic combustion control system is provided and controls the rate of combustion through the control of gas flow through the boiler setting and air heater, air flow to the stoker and coal feed by the stoker. The gas flow through the boiler setting and air heater is controlled, in proper relation to the load demand, by adjusting the damper at the outlet of the induced draft fan and by selecting the proper speed of the induced draft fan in response to changes in steam pressure in the main steam header. Air flow to the stoker is controlled by positioning the louvre damper at the outlet of the forced draft fan and by selecting the proper position of the drum controller in the secondary circuit of the slip ring motor driving the forced draft fan, all in response to furnace draft or pressure. The rate of coal feed by the stoker is controlled by positioning the control mechanism of the variable speed hydraulic stoker drive, in response to steam pressure, with compensation from the steam flow-air flow meter.

In addition to the master panel, each boiler is provided with a separate Bailey boiler panel, the instruments indicating the boiler drum pressure, superheater outlet pressure, draft at eight points, steam flow, and recording the steam flow, the temperatures of air entering air heater, air leaving air heater, flue gas entering air heater, and flue gas leaving air heater, the steam temperature, the boiler water level, the stoker speed and the relation of steam flow to air flow through the setting.

Instruments on the auxiliary bay panel, located on the firing floor, indicate discharge pressures at the boiler feed pumps, the heater pumps, and the soft water pumps, pressure in the deaerating heater and water levels in the house service water tank, the surge tank, the deaerating heater and the cold condensate storage well. The recorders on the same panel record temperatures in the surge tank and deaerating heater and the total feedwater flow. Indicating and recording instruments are provided throughout the plant to assist the operators, wherever possible, and to maintain a complete record of the actual performance of the equipment.

All generator and feeder circuits are controlled by electrically operated oil circuit breakers, installed in cells, as are all 13,800-v. buses, connections, instrument transformers, etc. The oil circuit breakers, the exciter and field carbon breakers and generator field rheostats are all contolled from the main control board installed in the switchbay overlooking the turbine room, and the operating energy for the devices is supplied by a storage battery maintained at full charge by a motor generator trickle charger.

The 2300-v. house service switching equipment, also electrically operated, is of the single breaker, double bus design. The main commercial load is supplied by three 13,000-v. loop feeders, fed from the 13,800-v. bus, while the new municipal water works plant is supplied directly from this plant by two 13,800-v. feeders fed from the 13,800-v. bus.

All circuits except the busway circuits are installed in galvanized conduit. Control circuits consist of multiple conductor, color coded station cables, with flameproof finishing braid, and no two control cables are installed in the same conduit. The 13,800 v. 3-conductor cables are shielded, paper insulated, lead covered and terminated in trifurcating joints and single conductor potheads, all maintained under positive oil pressure by means of oil pressure tanks. All outgoing feeder circuits leave the station underground and connect to overhead lines only at points sufficiently removed from the station to avoid the hazard of involving more than one circuit in a fault. All leaded cables are fireproofed in the manholes and in the cable room, where exposed to one another, to reduce the hazard of a fault in one cable involving another.

The distribution system is supplied by three transformer substations, namely Phenie, Lafayette and DuBois. A feeder line extends from the power plant to each transformer substation and, in addition, there is a tie line from the Phenie substation and the DuBois substation to the Lafayette substation. This arrangement provides at least two ways of serving each substation from the generating plant.

In order to insure reliability of service there are two complete underground, 13,800-v. circuits from the power plant to the recently constructed Three Rivers plant of the Water Works, terminating in a transforming and switching substation. All oil circuit breakers in this waterworks electrical energy supply system, from the power plant to the waterworks bus, are under the control of the power plant switchboard operator, by means of a supervisory control system.

Fig. 7. Coal storage and reclaiming equipment

DRAFT GAGES —

How to Select and Use Them

By CHARLES C. PHELPS

IN OUR EFFICIENT boiler plants, about 15 tons of air are employed to burn each ton of fuel to evaporate about 10 tons of water. Thus, on a weight basis, it may be said that these raw products—air, water, and fuel—rank in importance as 15:10:1. Still, a plant manager who would gladly spend several hundred dollars to purchase scales for weighing the fuel, and for a meter to measure the water, will often hesitate or flatly refuse to spend a fraction as much for a gage to measure the air. The reasons for this are manifold. Sometimes he does not realize how much the air really costs, and many do not appreciate the fact that a draft gage is in reality a means of measuring relative air quantity.

Air is one of the few remaining untaxed commodities. Paradoxical as it may seem, many plants would be better off financially if they were obliged to pay a cent or two of tax to the government for every ton of air they consume in operating their boilers. That would force them to measure the air used for combustion, with the aim of reducing the tax, and they would soon learn that reducing excessive air supply not only reduced the tax, but also reduced the fuel bill.

Too often plants are encountered where the ratio of air to fuel is not 15 to 1, but 30 to 1 or even worse. Undoubtedly, too often it is not understood that air in proportions above the necessary ratio acts merely as a diluent, reducing furnace temperature and decreasing heat absorption by the boiler. It is just common sense that if one ton of cold air is added to one ton of hot gases, the resulting mixture will attain a temperature which is the mean of the two and it will be obliged to travel through the passes of the boiler at about double the velocity; hence the time element, which is a factor in heat absorption, is cut in half.

Unfortunately it is seldom feasible actually to meter the air admitted to the boiler furnace, but it is very easy to admit air to give an ideal air-fuel ratio and from that to determine relative air flows with the aid of draft gages.

All commercial draft gages, irrespective of their principles of operation, are calibrated to read directly in corresponding water head, usually in inches or millimeters. Most gages read the difference between the atmospheric pressure and the pressure (positive or negative) at the point to which the gage is connected. Hence they are often referred to as "differential" draft gages. This sometimes leads to confusion, because the term differential draft gage is now generally understood to mean an instrument that shows the difference in draft between two points, other than the atmosphere, such as furnace and last pass of a boiler.

Forced Draft Applications

How can a draft gage be used to indicate air flow? Let us consider the case of a simple forced draft stoker-fired boiler, with draft gage connection beneath the stoker, to the furnace and to the last pass. We will assume 1 in. water-head pressure beneath the stoker and a balanced condition (zero pressure) in the furnace, for a load that requires 1 ton of fuel burned per hour. What should be the undergrate pressure for double this load, namely 2 tons per hour?

At first glance it might appear that the under-grate pressure should be 2 in. water-head. This, however, is not so, because the air flow is proportional to the square roots of the differences in pressure. In the first case the difference is 1 in. and its square root is also 1; in the second case the under-grate pressure would have to be 4 in., the square root of which is 2. So from this example we see that the operator can readily obtain the proper under-grate pressure, with the aid of his draft gage, in order to have the air supply match the rate of fuel feed.

In multi-zone types of stokers, the pressure in each zone must be indicated in order to avoid faulty distribution of air to the different sections of the fuel bed.

A still more important function of the draft gage is to keep watch on the furnace draft. In forced draft plants it is desirable to keep this as low as possible, usually about 0.05 in. and seldom above 0.1 in. The principal advantage of low furnace draft is the minimizing of infiltration of air through brick-work, cracks

in doors, clean-out openings, etc. Automatic furnace draft regulators frequently produce appreciable fuel savings merely by reducing these infiltration losses. The better furnace draft regulators maintain the draft within 0.01 in. or 0.02 in. of the predetermined reading, and hence it is necessary, in setting and checking them, to have at hand a draft gage that indicates accurately to 0.01 in. Thus it will be apparent that, whether dampers are operated automatically or manually, an accurate furnace draft gage is a valuable adjunct.

Natural Draft Applications

In natural draft boilers, furnace draft is utilized to draw air through the fuel bed in the case of coal or into the burner and furnace in the case of oil-fired boilers. The rating is increased by increasing furnace draft. If the boiler damper is operated manually, the furnace draft gage enables the fireman to duplicate the desired draft every time to match a given load. Further, it tends to safeguard against wide variations in draft, which are so conducive to inefficient operation. If a steam-pressure-actuated damper regulator is employed, a draft gage will avoid guesswork in calibrating the damper movement, that is, setting it so that it will "float" with the load and avoiding anything resembling a "wide-open-and-shut" characteristic, providing the regulator is of the compensated type, which it ought to be. If the average furnace draft in a natural draft plant can be reduced even 0.1 in., the gain in fuel economy should be well worth while. Many natural draft plants are operating at 0.5 in. or more furnace draft, when they could just as well operate at 0.2 in. or 0.3 in., with consequent reduced infiltration losses. Of course, with no furnace draft gage to guide him, the fireman cannot get the desired results.

The last pass or uptake draft, while less important than the furnace draft, is nevertheless worth measuring. Where two or more boilers are connected to a common breeching, it is frequently difficult to balance chimney "pull" among the boilers, the one nearest the chimney usually having the strongest draft effect. Sometimes elbows and turns in the breeching seriously impair the draft of one or more boilers. With a draft gage connected to the last pass, the damper setting can usually be made to correct these inequalities and force each boiler to carry its proper share of the load.

When draft gages are connected to both furnace and last pass, a simple means is thereby provided for watching the condition of the baffles. Any short-circuiting of the gases around a broken or defective baffle would be shown up by a decrease in the difference between furnace and last pass reading.

Utilizing the same square root law of gas flow, previously mentioned, it is possible to estimate the relative rating by noting the difference between furnace and last pass drafts; this is owing to the fact that the boiler load at any time is approximately proportional to the quantity of hot gases flowing through the boiler passages, although varying gas temperatures, soot deposits, etc., will affect this to some extent. Draft gages may be purchased having square root scales, so that the relative gas flow may be noted direct from the gage, without calculation.

Sometimes a draft gage of the true differential type is installed to measure the difference in draft direct on a single scale, for example the difference in draft between furnace and last pass. Where draft gages are employed primarily to insure equal or proportionate loads on two or more boilers, this is a desirable arrangement, but it has the disadvantage that the furnace draft cannot be read independently, without switching the last pass reading to atmosphere. Usually a better arrangement is to employ direct-reading draft gages, with a separate scale to indicate the draft or pressure at each point desired, as compared with atmospheric pressure. With the latter arrangement, the differential can still be determined by noting the differences on the scales. Marks may be made on the scales to show where the pointers, or indicating columns, should stand for given ratings, such as minimum, normal, and peak ratings. These points may be determined by making a series of Orsat tests, noting the drafts and pressures required to satisfy the steam demand, while at the same time producing the best

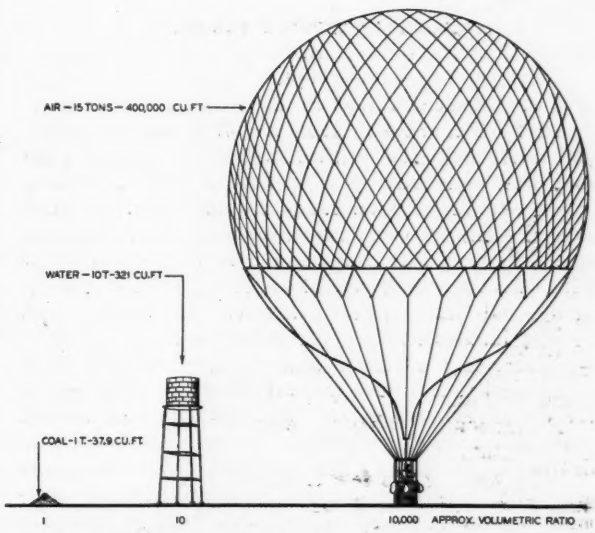

Diagram visualizing comparative volumes of coal, water and air necessary to effect combustion of the coal and evaporation of the water

obtainable CO_2 percentage in the exit gases, with no CO or only traces of CO present. Knowing what drafts and pressures should obtain for given boiler loads, it is comparatively easy, with the aid of draft gages, to insure the proper air supply continuously.

The draft gage, intelligently used, may supply other valuable operating information. For example, in a manually operated hand-fired boiler, a burnt-out spot in the fuel bed would allow more air to flow into the furnace, reducing the furnace draft. On the contrary, accumulation of ash and clinkers on the grates would be shown up by an increase in furnace draft.

With the aid of the draft gage, it should not be necessary to open firing doors so frequently to inspect the fires and to see whether the fuel bed is level or fuel bed is dirty or burnt out. This avoids the losses that accompany opening of the firing doors.

In furnaces with multi-zone windboxes, pressure gages connected to each zone are of great assistance in setting zone dampers and regulating air supply to each zone, so that the stoker does not "burn short".

With natural draft oil burners, furnace draft is

usually depended upon to draw the proper amount of air into the furnace, and small changes in draft may have marked effects on the resulting efficiency of combustion.

Certain fuels have a tendency to foul the gas passages rapidly. Such deposits result in increase of last pass or uptake draft and decrease of furnace draft. This effect may be of some help in deciding when to blow tubes, although a more positive way to determine this is by observing exit gas temperature.

Resistances of air preheaters and economizers may be readily determined with the aid of draft readings at entrance and exit of such equipment.

While cracks in boiler settings should be located by candle and Orsat determinations at regular intervals and sealed up with plastic material, it is advisable also to watch the draft gage for evidence of infiltration losses. For example, if a clean-out door were accidentally left ajar, the draft gage would give the operator immediate warning that all was not as it should be.

To select windbox pressure ranges, it is best to depend upon the fan manufacturer's recommendations.

To select last pass or uptake ranges, it is best to provide sufficient range to meet maximum chimney "pull". With ordinary fuels it will be safe to assume 0.01 in. of draft for each 2 ft. elevation between point measured and chimney top. Thus a 150 ft. chimney would suggest 0.75 in. range for the gage. For furnaces burning refuse, such as sawdust, wood shavings, etc., a higher draft range would be desirable because with such fuels excessive amounts are burned momentarily and chimney temperature, and hence draft, become intensified for short intervals.

Where such excessive drafts may be expected only momentarily, it would be still better to select gages for the normal range, and to provide the gages with seals which safeguard them against these excessive drafts. In the case of induced draft boilers, seals are especially to be recommended because surges are common in starting up an induced draft fan or suddenly changing its speed. Seals can also be provided to protect draft gages against momentary excess plus pressures, as when blowing soot from tubes.

Especially in selecting furnace draft scales, the range should be restricted to the actual range to be encountered, depending upon seals to take care of possible excess draft conditions. This will insure maximum legibility and accuracy. For oil burning, zero to minus 0.25 in. or zero to minus 0.5 in. are usually suitable furnace ranges. For natural draft, coal-burning furnaces, zero to minus 0.5 in. or zero to minus 1 in. are common furnace ranges. For forced draft, coal-burning boilers, the furnace draft should be carried so near atmospheric pressure that it is often desirable to have available a little plus pressure on the scale, hence common ranges for such service are plus 0.1 in. to minus 0.5 in. or perhaps plus 0.2 in. to minus 0.8 in.

In all cases, each gage should be equipped with a well made non-sticking shut-off cock with an atmospheric vent so that the reading can be checked at zero instantly, merely by turning the cock.

Any draft gages selected for boiler room use should be entirely enclosed and dust-proof. Sometimes open type gages are used for such service. The open type is lighter and hence more suitable for portable use, but should never be employed for stationary service, because it soon becomes covered with dust and grime, and it is then difficult to observe. For the same reason, the draft gage should be well illuminated and placed where the operator can see it at all times, and it will give better service if not exposed to more excessive heat than absolutely necessary.

The draft gage can be either just "another gadget" or one of the most useful tools in the hands of the boiler room operator. That depends upon whether its purpose is understood by the operator and whether he has the will to apply the valuable information which it gives him.

Red Cross First Aid Safeguards Industrial Workers

EACH year employers of labor in increasing numbers realize the value when emergencies arise of teaching first aid to key men in the industry and personnel records reveal that among those trained in first aid the percentage of accidents is markedly low.

An excellent by-product of first aid training has been the decrease in the accident frequency records of groups which have received this instruction. As men are taught the danger of infection from untreated wounds and the serious aftermath experienced from accidents generally, they become more accident conscious and thus more alert to avoid the hazards of their occupations. Not only are first aiders of benefit to their fellow workers and an asset to the firm that employs them, but they take their helpful knowledge home with them and are safety sentinels of their neighborhoods, ready to aid in emergencies.

Red Cross first aid training in industry, like in disaster, nursing, veteran and civilian relief programs, is supported by the annual membership dues of citizens who join the Red Cross during Roll Call. You can share in the work of your Red Cross by enrolling as a member, November 11 to 28.

WATER WALLS *for* Higher Heat Release

Many of the Improvements in Boiler Room Operation Can Be Traced to the Development and Use of Water Walls of Different Types

By B. L. SPIVAK, M. E.
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MANY OF THE ADVANCES made in power plant design and practice can be attributed to the development of water walls. As furnace lining, they make possible elevated furnace temperatures without the dangers of reducing wall strength, of fluxing, of slagging and of erosion. In addition, they provide a highly efficient heat absorbing surface, reduce wall radiation losses, make possible thinner wall construction, accommodate rapid load fluctuation, and protect burning equipment parts. Their use has raised tremendously the steaming capacities of boiler units. They have brought about the economies inherent in smaller furnaces, low wall maintenance, low excess air requirements, and the use of coal containing ash that fuses at a low temperature.

Various types of water walls have been developed. The type shown in Fig. 1 is a bare tube placed in front of a refractory wall. It protects the refractory against high surface temperatures and against slagging to a considerable degree. It receives heat not only by radiation from the fire but also by reflection from the refractory wall. Ignition of fresh fuel is assisted by the refractory surface. This form is considerably in use as radiant superheater and reheater elements. The size of tubes, tube spacing, and distance from wall all vary to suit the thermal need. A variation of this type is shown in Fig. 2. It affords more protection to the refractory. In some cases the tile is placed just touching the back of the tubes. The front walls of the furnaces of the latest installation at Hudson Avenue are of this type. The walls are made of 3 in. tubes spaced 3¾ in. center to center.

Thin Walls

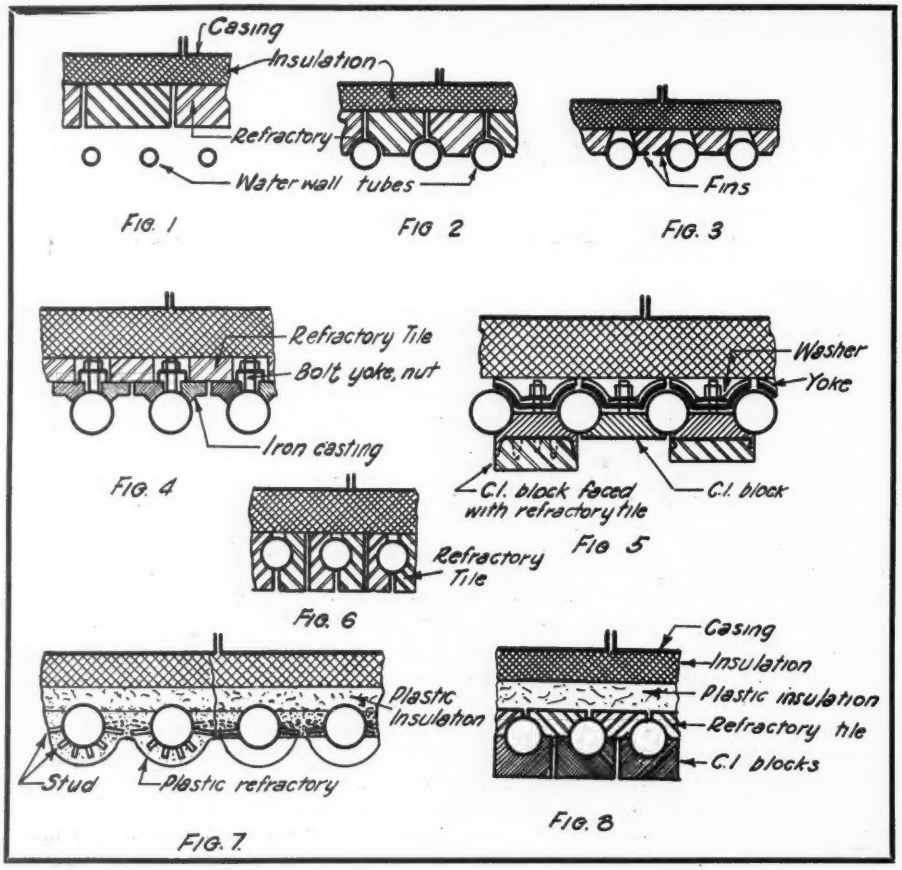
Figure 3 shows the fin tube type. Tubes are usually 4 in. in diameter with a ¼ in. thick fin welded to the side. The space between the fins of adjacent tubes is about ⅛ in. Sometimes a U-shaped tile is used to back the tubes. The tile fits around the rear part of the tube and back of the fin. It is interesting to note that the installation of the large stokers in the Hudson Avenue station was possible only because of the extra space made available by the thinness of this type of wall. The walls are of 4 in. tubes spaced 6⅛ in. center to center.

A wing back water wall is shown in Fig. 4. The bolts are welded to the tubes. The iron casting is machined to give close contact with the tubes. There is space between adjacent blocks to accommodate expansion. The greater portion of each tube is exposed to the radiation from the fire and re-radiation from the iron block.

In Fig. 5 is illustrated a block wall, consisting of a block fitting between two adjacent tubes. The block is held against the tubes by a yoke and nut as shown. A good thermal cement is used on the surface of contact between block and tubes. The block construction varies. There is a cast iron block with smooth surface, and one with a grooved surface. The middle block in the figure is the smooth cast iron type. The grooved type is similar in construction except that the furnace side is roughened. The former is used for high cooling effect, the latter acquires a coating of slag which is held by the rough surface and which reduces heat absorption.

If heat absorption is to be further reduced, the cast iron block is faced by appropriate refractory of required thickness, as shown in the figure at the extreme left. It is made by pouring the iron on the refractory tile so that the resulting cast iron block forms an intimate bond with the tile, which bond is assisted by the projecting lugs of cast iron extending into the tile, as well as by the gripping effect of the rim. In the block at the extreme right of the figure, the tile is bonded to the block by thermal cement and dovetail construction of the rim. In the latest addition to the Hell Gate station, the three types—refractory faced, smooth cast iron, and grooved cast iron blocks are used.

For thirteen feet above the furnace floor, refractory covered blocks are used. This type was chosen to protect the tubes against excessive wall temperatures and to promote ignition of fresh fuel at low ratings. Above this zone is a 3 ft. layer of grooved iron blocks. The rest of the furnace wall above this is of smooth cast iron block construction. The rough-faced blocks accumulate a layer of slag which auto-



Various water wall constructions available for modern furnaces

matically adjusts itself in thickness to the rate of firing of the furnace. The smooth blocks cool the furnace gases as much as possible just previous to their entry into the boiler passes and thus reduce the slagging of the boiler tubes in the first pass.

Variable Refractory Thickness

A refractory-faced water cooled wall is shown in Fig. 6. The individual tiles may be so shaped that they can be slipped into place from the furnace side. There are various forms of this type, each featuring some method of interlock for proper tile support and ease of erection and repair. This type is limited to those installations where the limited cooling effect possible is sufficient to inhibit slag accumulation and fluxing.

A wall designed for plastic refractory facing is shown in Fig. 7. Studs of varying length are welded to the tube, the longer ones being at the sides and the shorter ones in between. The refractory of desired thermal conductivity and thickness is applied to the furnace side of the tubes. If desired, the refractory can be applied only between tubes, and a portion of the tubes exposed to direct radiation. Both are shown in the figure. An interesting application of the stud tube is found in the latest unit installed in the State Line station. The slag screen stretching across the top of the furnace consists of 2 $\frac{11}{16}$-in. stud tubes covered with plastic refractory to an outside diameter of 5 in. They are arranged in a horizontal series of V-shaped groups so placed that the gases flowing from the furnace will be deflected by the refractory surfaces of the V's before entering the boiler passes.

Impingement of the gases on these surfaces causes fly ash to deposit on them. The ash remains fluid, and drips to the furnace floor which is of the slag bottom type. It is interesting to note that the heat release rate in the furnace below the slag screen is in excess of 50,000 B.t.u. per cu. ft. If the volume above the screen is also considered, the heat release rate is 35,000 B.t.u. per cu. ft. Compared to the usual rates in pulverized coal furnaces of standard dry bottom design, these are very high.

In Fig. 8 is shown a wall formed by fusing cast iron blocks on the water wall tubes as used in the Hudson Avenue installation. It extends 5 ft. above the stoker level and forms part of the side walls. It protects the side wall tubes from erosion by the moving fuel bed. The fusing of the blocks and tubes assures perfect thermal contact between tube and block.

As an instance of the sturdiness of nickel cast iron gears, in a deep-well unit, driven by a 3-hp. motor, the plunger cage broke and jammed in the lower cylinder during test, the ½-in. steel pipe used as a plunger rod being pulled in two on the up stroke. On examination it was found that no damage had occurred to the nickel cast iron driving gears although gear teeth in common cast iron gears have pulled out and jammed, resulting in sprung shafts and cracked bearings when similar accidents have happened in other places.

Effect of Soot on Boiler Heat Transmission

By P. Nicholls[1] and C. E. Augustine[1]

SOOT ON THE HEATING SURFACES of a boiler decreases efficiency because it increases resistance to the flow of heat, with the result that the heat transfer to the water is lower and the temperature of the flue gas higher than they would be if the surfaces remained clean. The percentage of reduction in heat transfer depends on the position and area of the sooted surfaces, the thickness of the soot, and the percentage of the total heat absorbed by those surfaces when clean; thus it will vary with the type of boiler and in particular with the ratio of the area of the convection heating surface to the total area.

Medium-size and large boilers usually are equipped with soot blowers and tests have been published giving the increase in efficiency resulting from removal of the soot. Savings may not be due wholly to a reduction in the thermal resistance of the surfaces but may be due partly to improvement in the combustion because of better draft or more uniform flow of the gases. In addition, the deposits on the surface of boilers include ash and clinker, and as the size of the boiler and the rate of burning increase, very little or none will be soot.

There are no corresponding test data on small boilers operated at low rates of burning. In small boilers, deposits are much thicker, and it might be expected that the reduction in efficiency would be greater; in fact, statements have appeared suggesting that the decrease may be as high as 50 per cent. This investigation was undertaken because the Bureau frequently receives requests for authoritative information on the effect of soot in small and heating boilers.

To obtain the test results on small boilers it was necessary to use somewhat novel test methods which are summarized as follows: Two boilers were tested, both of the round cast-iron type with three sections. The methods used were the same in both boilers. The tests simulated a heat-transmission test in which hot gases of a definite weight per hour and a definite temperature were passed through the boiler; the heat transfer was determined from the heat delivered and from the temperature of the gases leaving the boiler. This was accomplished by burning high-temperature coke, supplying a definite total weight of air per hour and continually adjusting the rates of primary and secondary air so that the CO_2 content of the flue gases was constant for 5 hr. and was the same in successive tests.

[1]Pittsburgh Experiment Station, U. S. Bureau of Mines. This material was abstracted from U. S. Bureau of Mines Report of Investigations 3272.

In the first test the heating surfaces were thoroughly cleaned. The sooting was then accomplished as an independent operation by burning coal in the normal manner with natural draft. After a light sooting another test was made, after which the boiler was further sooted and again tested; this was repeated until no further increase in soot was possible. Finally the boiler was again cleaned and retested. The table summarizes the results of the tests and shows the heat loss, that is, heat not absorbed by the boiler, caused by various degrees of sooting, expressed as a percentage of the heat made available to the boiler.

Heat Loss Caused by Soot Expressed as a Percentage of the Heat Made Available by the Burning of the Fuel

Degree of sooting	20-inch boiler Test No.	20-inch boiler Heat loss, per cent	24-inch boiler Test No.	24-inch boiler Heat loss, per cent
Clean	1	0	1 and 2	0
Slight (⅛ inch)	2	3.0	3	1.5
Medium (¼ inch)	3	4.9	4	4.2
Heavy	4	6.4	5	4.2
Do.	5	5.7	6	4.7
Do.	6	5.0	8	5.3
Do.	7	6.6	..	..
Clean	8	0	7	0

The loss with the first thin layer of soot is greater than that with further increases in the quantity deposited. This may be due to the fact that the surfaces of the firepot were cleaned, and the layer of tar deposited on these may have decreased their ability to absorb the radiation from the fuel bed. The maximum loss in any test was 6.6 per cent with the 20-inch and 5.3 with the 24-inch boiler. The deposits in these tests were very heavy and more than would be tolerated in service. The rates of burning used in these tests were 2½ and 3 lb. per sq. ft. per hr.

It should be noted that the loss of heat has been expressed as a percentage of the heat made available and not of the heat in the fuel. The heat made available is equal to the heat in the coal minus the heat in the combustible lost to the ash-pit and the heat in the unconsumed combustible in the gases; therefore, the loss due to soot expressed as a percentage of the coal burned will be less than the values given in the table. The average loss to the ash-pit can be taken as 4 per

cent of the combustible in the coal; the loss of combustible in the gases will vary widely with the season of the year and the method of firing and care taken, but a value of 8 per cent may be a general average. This makes a total of 12 per cent, and the loss expressed as coal fired would be the values given multiplied by 0.88, which would reduce the maximum of 6.6 to 5.0 per cent.

The main objection against soot is that the clogging of the passages causes insufficient or unsatisfactory heating. Lack of draft also results in waste of fuel in addition to the loss due to the insulating effect of the soot. Values for this additional loss cannot be given, and they may be low or very high. The direct cause of this loss is the fact that insufficient air is drawn in through the door slots and thus combustible gases pass to the chimney unconsumed. That this occurs is evidenced by the fact that insufficient draft is usually accompanied and indicated by smoking at the firing door.

With sufficient draft the ash-pit damper can be partly closed so as to give a higher draft over the fuel bed and thus draw in air through the door slots, or the same result may be accomplished by leaving ashes on the grate or maintaining a deeper fuel bed. If the fire does not burn rapidly enough because of lack of draft the attendant will open the ash-pit damper wide and shake the fuel bed so that its resistance to air flow becomes very low; both actions will reduce the quantity of air drawn in through the door slots.

A secondary cause for loss because of insufficient draft is the fact that more combustible is lost to the ash-pit because of the necessity of shaking the grates. Losses from these causes may be 25 per cent or more of the coal burned; on the other hand, such conditions will not be allowed to persist for long and the furnace will be cleaned.

It was recognized that a limited number of tests of two boilers would no more than indicate the order of the losses caused by soot in boilers, but it is probably safe to make the following generalizations with reference to heating boilers:

The tests showed that in round, cast-iron boilers with three intermediate sections, that is, a ratio of effective secondary to total heating surface of about 0.4, operated at the average rate for a heating season the insulating effect of deposits of soot decreased the heat absorbed by the boilers 2 to 7 per cent of the heat made available by the fuel, depending on the thickness of the deposit.

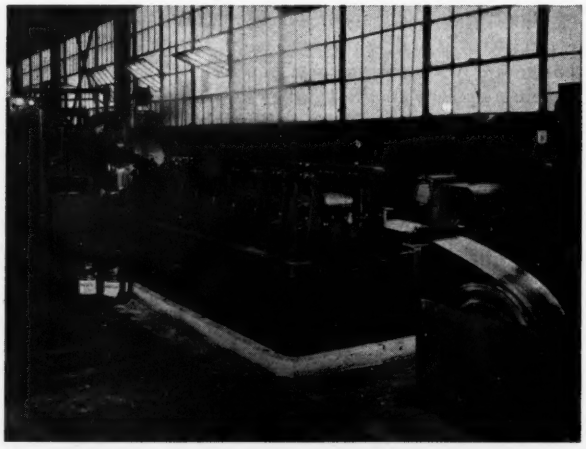
Losses, expressed as a percentage of the coal burned, will be less and will be approximately proportional to the over-all efficiency. Thus with 60 per cent efficiency, about 1¼ to 4¼ per cent of the coal will be wasted because of the insulating effect of the soot. The loss will be less as the number of sections is less, that is, as there is less secondary heating surface.

Until further tests are made these values can be accepted as applying to other types of heating boilers with the same ratio of secondary to total heating surface. These values do not include the waste of fuel that may result from incomplete combustion due to insufficient draft caused by the soot clogging the passages or flue, which may, and usually will be, much greater than the loss caused by the insulating effect.

Automatic Welding of Transformer Radiator Tubes

AN INGENIOUS MACHINE which performs six different operations, is used at the Pittsburgh Plant of the Allis-Chalmers Manufacturing Company, in the fabrication of radiator tubes for transformers.

This machine, shown in accompanying illustrations, takes strip steel, presses a series of grooves into it, folds it over, crimps the two edges, welds them together and then cuts off the welded tube into proper lengths.



Operation of the machine is entirely automatic. The machine turns out a 12 ft. tube every 1.2 min. This high fabricating speed is made possible by the automatic shielded carbon arc process of welding.

As shown in the illustration strip steel 9⅝ in. wide, 16 gage is drawn into the machine. This strip passes between rollers which press six grooves into it. The grooved strip is then folded over and the edges crimped. The formed tube then passes under the carbon arc which welds the edges together. The welded tube emerges from the machine in a continuous piece. A saw, which travels in the same direction and at the same speed as the tube, cuts off the correct lengths—5 to 10 ft. long, as required.

The automatic shielded carbon arc process of welding known as the Electronic Tornado system used in fabricating these radiator tubes, was developed by The Lincoln Electric Company, Cleveland, Ohio. This process utilizes a controlled atmosphere around the carbon arc which prevents oxidation of the weld metal. It provides great savings in fabricating costs where large numbers of products of uniform character are manufactured.

Combustion Control

Part X. Cash Standard Automatic Combustion Control Equipment for controlling the rate of combustion by regulation of the rate of fuel feed, air supply and furnace draft with facilities for shifting to manual control

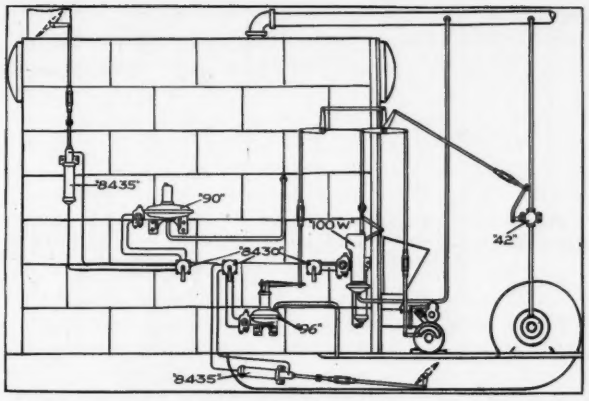


Fig. 1. Typical application of Cash control to forced draft stoker

ARRANGEMENT OF COMBUSTION CONTROL EQUIPMENT for any particular installation depends to a large extent upon the type and design of the major equipment. In some cases the separate control units may operate independently, while in others for best results the various units should bear some definite and variable relation to each other. Both of these cases are illustrated by Fig. 1, a typical arrangement of Cash Standard Automatic Control to a forced draft stoker fired installation in which the fuel feed, air for combustion and furnace draft are under automatic control.

Rate of fuel feed is governed by a Type 100-W controller which regulates the speed of the stoker driving unit according to changes in load as reflected in the boiler steam pressure. Air for combustion is regulated by a Type 96 Controller, the diaphragm chamber of which is connected to the air duct or stoker wind box. This Controller is responsive to changes in air pressure at this point, but is coördinated with the action of the steam pressure Controller, to vary the duct pressure so as to give a supply of air proportional to the rate of fuel feed. As the boiler load changes, the Type 100-W Controller changes the rate of fuel feed and readjusts the Type 96 Controller to maintain the desired fuel-air ratio. Furnace draft is maintained by a Type 90 Controller which operates the uptake damper. It is actuated by the furnace pressure, and is independent of the other two Controllers, and maintains the desired furnace draft regardless of changes in boiler load, fuel feed or air supply.

Details of the Master Controller, the Type 100-W, are shown in Figs. 4 and 4-A, while those of the Type 90 Controllers are shown in Fig. 5. The Type 96 Controller as shown in Fig. 1 for controlling the forced draft air supply, is of the same general type as the Type 90, except that the manual adjusting screw is replaced by a lever which when actuated by the Type 100-W master controller adjusts the air pressure to correspond with changes in fuel feed. As shown in Fig. 1, the power cylinder may be conveniently located near the equipment to be regulated.

By the addition of the hand control valve, Fig. 7, automatic control may be instantly interrupted and the unit under control placed in any desired position, where it may be held indefinitely. When the pointer of the hand control valve is at A the power cylinder will be moved automatically and the operating fluid will flow through the hand control valve without change. When the lever is turned to O the hand control valve cuts off the automatic control and directs the flow of the operating fluid to the power cylinder so that the attached unit will be moved toward the open position. Moving the lever to C reverses the flow to the power cylinder so that the unit under control is moved toward the closed position. All movements of the power cylinder are arrested when the lever is at S. When desired, the hand control valve

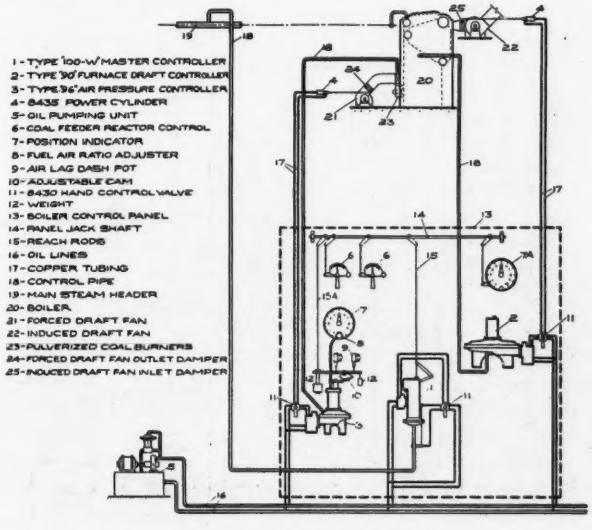


Fig. 2. Unit fired pulverized coal installation

Changes of steam pressure in the main steam header 19 actuates the Type 100W Master Controller 1 which rotates panel jack shaft 14 to increase or decrease the fuel feed through reactor controls 6. The rate of fuel feed is indicated on the position indicator 7A. At the same time rotation of the jackshaft 14 moves reach rod 15A and through weights 12, air lag dash pots 9 and square root cam 10, varies the spring adjustment of the Type 96 controller 3 so as to change the air pressure at the burner and maintain the desired fuel-air ratio. The adjustable square root cam 10 is designed to produce the necessary square root relation between air pressure and air flow to maintain at all loads the fuel-air ratio set by the fuel-air ratio adjuster 8. The air lag dash pots 9 and weights 12 take care of the time lag of coal from the feeder through the mill to the burner. The type 96 controller 3 is an adaptation of the 90 controller shown by Fig. 5, the motion of the cam 10 being transmitted to the balancing spring within the controller case. Furnace draft is maintained constant by the type 90 controller 2.

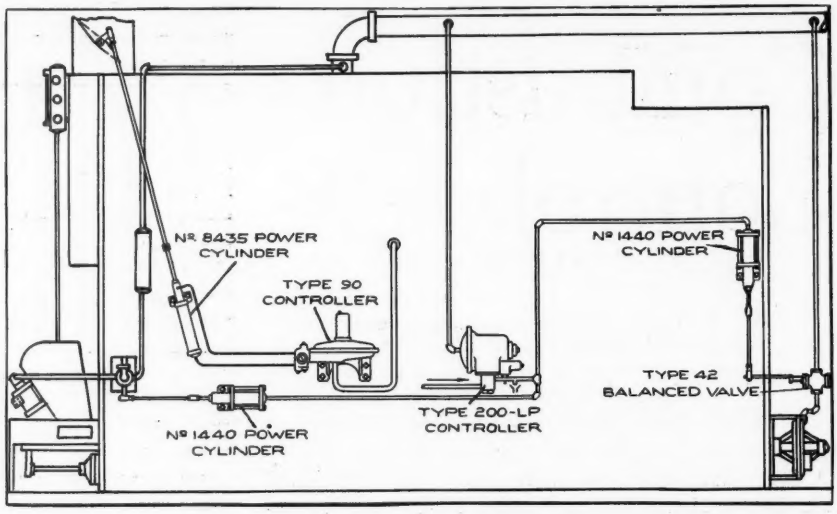


Fig. 3. The type 200 controller applied to the stoker fired installation

may be mounted directly on the controller. If, however, it is more convenient, the valve may be located at the front of the boiler or on the instruument panel and connected to the power cylinder and the pilot valve of the controller through copper tubing.

Another method of manual control may be obtained by substituting the hand operator and power cylinder, Fig. 8, for the standard cylinder. When using the hand operator and power cylinder it is necessary that the cylinder be located at some accessible place. To interrupt automatic control and to manually adjust the unit under control, the operator moves the lever L, Fig. 8, to the left and turns the hand crank until the piston and unit to which it is attached reach the desired position. The star wheel is then turned to the right to hold the gear stationary.

Figure 2 is a similar control system applied to a unit burning pulverized coal. The rate of fuel feed is governed by the Type 100-W controller through the coal feeder reacter controls. The type 96 air pressure controller and the Type 90 furnace draft controller are applied to this unit in a manner as described for the forced draft stoker fired unit, Fig. 1. In order to match the air supply to the straight line action of the pulverizer coal feeder, the air pressure adjustment at the Type 96 controller is made through a suitable cam designed to produce the necessary square root relation between the air pressure and air volume. The face contour of this cam is made adjustable within suitable limits to make minor corrective adjustments in the field. The air control is also provided with air lag dash pots and related devices to produce a definite time interval (adjustable in the field) between master controller movements and corresponding readjustments of the air controller to compensate for the time lag between the adjustment of the coal being fed into the pulverizer and the actual response in the amount of pulverized coal delivered through the burners and into the furnace. Thus the air supply adjustment is

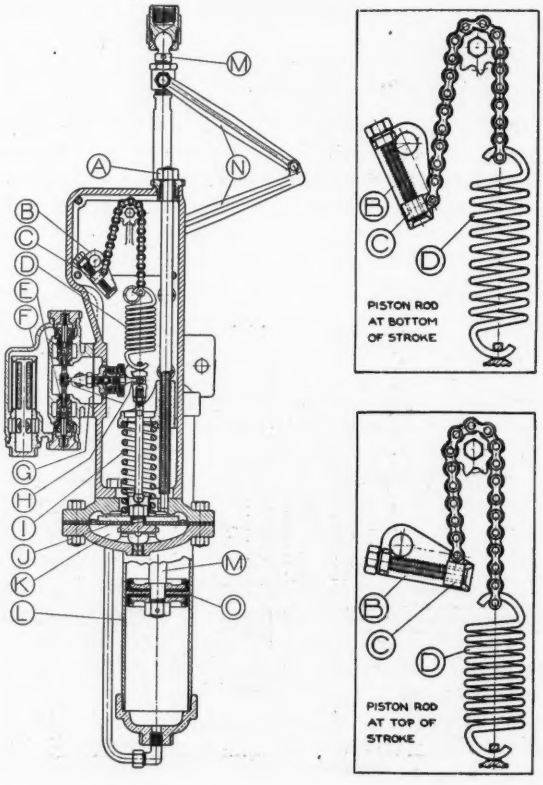


Fig. 4. Details of Cash Standard Type 100 Series Master Controllers

Consider the controller in service maintaining the desired fluid pressure and power piston O is at rest. A slight change in the pressure of the fluid under control causes positive movement of control diaphragm J. The full-floating lever H transmits this movement to the four-way valve F which selectively energizes the correct side of power piston O, (and simultaneously exhausts the other side) so that the piston rod moves to operate the apparatus under control in the right direction to restore the desired fluid pressure under control. At the same time (through link and lever N, compensating lever B, and roller chain) this power piston movement has been transmitted to the compensating spring D to change its tension, increasing or decreasing its tension according to the direction of power piston movement. This alters the effective spring load on control diaphragm J and brings the piston rod to rest at the proper position.

As the piston rod moves it oscillates the compensator lever B, being connected to it by link and lever N. Detail drawings at the right show the compensator lever at its extreme positions of oscillation and illustrates how piston rod movement results in a change of tension on the compensating spring D, to change the effective load on the control diaphragm, thus bringing the power piston to rest at a position in its stroke that corresponds to the pressure on control diaphragm J.

Diaphragm G with lever H constitutes a diaphragm bearing which permits frictionless movement without play or lost motion so the slightest movement of control diaphragm J is transmitted to the four-way valve F.

For ease of description, this Controller has been described as though it worked by stages, or in steps but in operation it works in a smooth floating manner, without hunting or over-shooting.

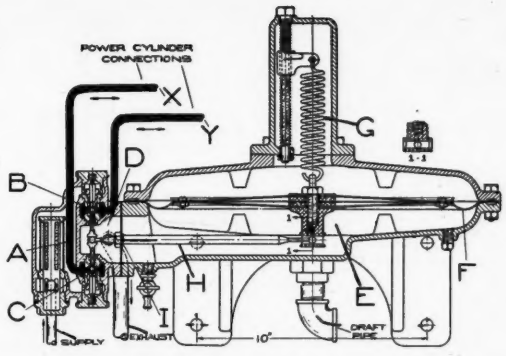


Fig. 5. Cross section showing details of Cash Standard Type 90 Furnace Draft Controller

The draft in the furnace is communicated through the draft pipe to chamber E where it acts on diaphragm F being counterbalanced by spring G which is adjustable. A slight change in draft will move diaphragm F and this movement is transmitted through lever H and diaphragm I to operate ball valves B and C simultaneously. Operating fluid, oil, air or water, under pressure, is admitted through the strainer to pressure chamber A, so that it is effective above ball valve B and below ball valve C while the opposite side communicates with exhaust chamber D. Through these valves B and C the operating fluid flows to one side of the power cylinder and is exhausted from the other.

Valves B and C act simultaneously and each valve is double acting in itself. That is, when valve B opens its admission port, it closes the exhaust port; when valve C opens its exhaust port, it closes its admission port, and vice versa. A slight increase in draft will adjust valve C to energize one chamber in the power cylinder and at the same time it will adjust valve B to exhaust the other chamber in the power cylinder. The power piston will immediately close the uptake damper enough to restore the draft for which the Controller is adjusted.

The Type 96 Controller shown in Figs. 1 and 2 is fundamentally the same as the Type 90, but is fitted with an adjusting lever, which replaces the adjusting screw. This provides means for remote control through a predetermined range.

caused to lag behind the coal feed adjustment in order to prevent a disturbed fuel-air ratio and a resultant uneven CO_2. The time lag is confined to the regulator adjustments, and does not slow down the action of the power cylinders in response to changes in the control pressure.

Changing Fuel-air Ratio

Means are provided for making minor corrective adjustments as may be required in the fuel-air ratio without interrupting the automatic control, and the position of this adjustment is shown by a dial type indicator which is located alongside the fuel-air ratio adjuster to guide the operator in making the necessary adjustments which may be called for due to variations in coal sizing or moisture content.

Figure 3 shows a steam pressure actuated controller of another type, applied to a forced draft stoker fired boiler. This Type 200 controller with its power cylinders is commonly used to govern engine or turbine driven fans, by operating a balanced valve, a chronometer valve, or by automatically adjusting certain types of ball governors. For electric drive it operates a rheostat. With constant speed fans, it controls either blast gates, fan outlet, or fan inlet dampers. For fuel feed control it governs steam driven stoker engines by coöperating with an engine governor, or by operating the hydraulic valve or the fuel control levers normally furnished by stoker manufacturers with their equipment. On gas or oil fired boilers it operates balanced valves to govern fuel feed. There are many other uses, the above being merely typical.

Application of Control Systems

For simplicity, examples of the application of Cash Standard Automatic Combustion Control have been for one-boiler jobs only. It is not the intention to convey the idea that such control is adaptable to plants containing only one boiler. This control may be successfully applied to boiler plants containing a plurality of boilers of any size and to plants where various types of fuel burning equipment are employed. It will also be noticed that in Figs. 1 and 3, controllers are mounted on boiler or building structural steel work. In many installations such controllers have been mounted on boiler instrument panels in order to provide a centralized control system. Figure 2 more clearly illustrates this type of control system.

Plants with Two or More Boilers

Generally, the control panel is supplied by the control manufacturer, provision being made for the mounting of all boiler instruments and gages, with ample room being left for the location of the various

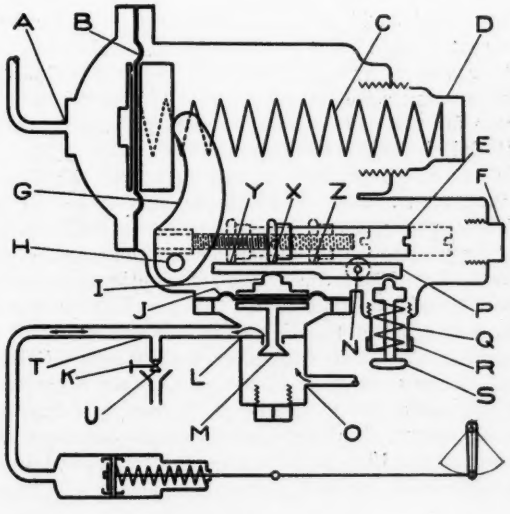


Fig. 6. The Cash Standard Type 200 Pressure Controller

Steam boiler pressure is connected at A where it is effective on spring loaded diaphragm B. The operating fluid, water, air, or oil, under pressure, is piped to O where it is throttled by valve M. Valve outlet L is piped to the power cylinder to operate it. A V-port bleeder K is used in this pipe: the bleeder being discharged to open drain.

The larger diaphragm B moves in response to changes in boiler pressure, and its movement is transmitted through bell crank G to the smaller diaphragm J. As this smaller diaphragm moves, it changes the pressure and rate of flow through valve M. When an increase in boiler presseure produces a corresponding increase in this rate of flow through valve M, the flow immediately begins to gain on bleeder K. This causes an increased operating pressure in the power cylinder which forces the power piston outward a corresponding amount (gradually compressing the piston spring). When boiler pressure decreases, bleeder K immediately gains on the valve M, cylinder pressure decreases, and the spring moves the power piston back the amount of movement corresponding to the pressure change.

The amount the piston moves, per unit change in boiler pressure, is determined by the setting of the range adjustment. One arm of bell crank G is threaded to accommodate pivot point adjusting sleeve E. Interposed between this sleeve and pusher plate I is rocker plate P, which rocks on bearing N. This is for the purpose of varying the effective length of one arm of the bell crank, made shortest when the pivot point is at Y, and longest when at Z. Varying the length of this arm varies the effect of diaphragm B movements on diaphragm J. The position of the pivot point determines the amount the power piston moves per unit change in boiler pressure. The range is least when the pivot point is at Y, and greatest at Z.

When used to operate the uptake damper, a convenient standby adjustment is provided. At night, when fuel feed and air supply are shut off, hand nut R is adjusted to compress its spring Q sufficiently to move the damper to the desired position and lock it there. This makes it unnecessary to disconnect any linkage to move the damper. Note that when spring Q is under compression, it applies its load to valve M, and thus assumes independent control of the operating fluid.

controllers, regulating devices, control valves, indicators, etc. All controllers, devices, etc., are completely mounted and connected by the manufacturer. The erection is thus greatly simplified.

With the centralized type of control it becomes possible for the operator to see at a glance under just what conditions a unit is operating, and without the necessity of going from one regulator to another, as is necessary in the ordinary type of control, he can make any minor adjustments that may be necessary, or he may assume partial or complete manual control of the unit at the control panel.

Cash standard hand control valves as described in this article may be used to advantage for providing manual control of the units to be regulated. These valves are of such design that they may be mounted on the face of the control panel and may be used for hydraulically adjusting the device to be controlled, or for changing back from manual to automatic control. It is readily understood that these centralized control systems have a decided advantage, especially from the operator's standpoint.

When applying automatic combustion control to a plurality of boilers, it is most desirable that the master controller (the heart of the control system) be common to all units, so that pressure changes as caused by an increase or decrease in boiler load will cause a response in the rate of combustion at each of the boilers to maintain the desired load distribution.

Fig. 7. Hand Control Valve

Number 8430 hand control valve may be interposed between the power cylinders and pilot valves of any of the Type 90 Series of controllers, or it may be similarly installed on the Type 100 Series of controllers.

This valve consists of one movable and one stationary plate, both of which have ground faces. The stationary plate is provided with six outlets; two of which are connected to the power cylinder, two to the pilot valve of the Controller, one to the operating fluid supply, and one to the drain. Suitable grooved passages are also provided in the stationary plate. The valve or movable plate may be rotated by the handle and has two short grooved passages which, when rotated, connect the outlets in different combinations to allow automatic or manual operation of the power cylinder. When the pointer is changed to O, the operating fluid passes directly to the power cylinder, causing the power piston to move in the opening direction. Moving the pointer to C will reverse the flow of the operating medium and cause this power piston to move toward the closed position. When the pointer rests on S, the pressure is trapped on both sides of the power piston and no further movement of the piston can occur. When the pointer is changed to A the operating fluid will pass directly from the pilot valve of the Controller to the power cylinder, thus providing automatic regulation of the unit to which it is connected.

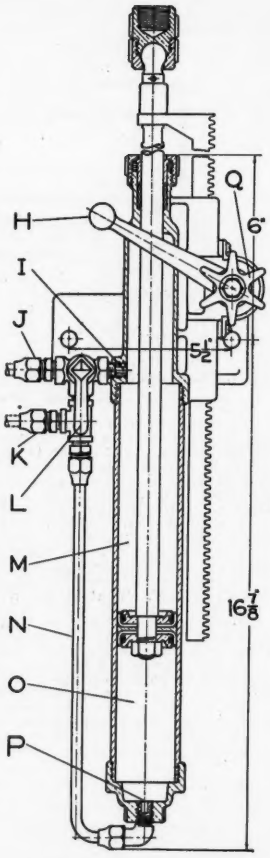
The furnace draft controllers, air pressure controllers, etc., are in most instances duplicated for each boiler. The necessity for this is more easily understood when it is considered that all boilers have different operating characteristics, and may not operate efficiently at the same draft, nor is the loss through any two boilers necessarily the same, even though they may be of the same type. Then too, the air pressure to the furnace can be more efficiently regulated to maintain

Fig. 8. Details of the Cash Standard Hand Operator and Power Cylinder

Number 8440 hand operator and power cylinder may be substituted for the power cylinder usually furnished with the Type 90 Series of Controllers.

Normally, the power cylinder is under automatic control with the Star Wheel Q loose and the small lever L in a vertical position. One fluid pressure operating line from the automatic control is serving chamber M above the piston, through fitting J and port I, the other fluid pressure line from the controller serving chamber O below the piston, through fitting K, tube N, and port P. To switch the power cylinder to hand control, the lever L is turned clockwise 90 deg. to a horizontal position. The piston may then be operated by means of the hand crank H and locked in position by tightening star wheel Q. Movement of lever L to a horizontal position operates the three-way valve to stop the flow through the fitting J. At the same time it connects chamber O below the piston, through port I, tube N, and port P, thus equalizing pressure on both sides of the piston and making it easy to operate the damper by hand through the hand crank and gearing. The type 100 Series of Controllers may be provided with similar hand operator and power cylinders.

The No. 8435 power cylinder shown in Fig. 1 is, in general, the same as the No. 8440 with the three way valve, rack and lever removed. The 8435 may be controlled by hand by means of the hand control valve 8430 (Fig. 7) installed as shown in Fig. 1.



the desired fuel-air ratio by having individual controllers so that the air supply to one unit may be varied with the relation to the supply to another in order to compensate for variations in types of fuel burning equipment, duct and wind box design, and the location and arrangement of air control dampers.

IN AN ARTICLE in Engineering of London, David Brownlie gives some interesting statistics as to energy production and the use of power in the world from 1910 to 1933. Coal production has ranged from 955 million to 1,323 million tons a year, the maximum being in 1929. Over a 10-yr. period, the United States has produced 34.24 per cent, Germany 20.73 per cent and Great Britain 16.96 per cent of the world's supply, no other country having over 3.66 per cent, but Russia's output has increased rapidly. Also Germany's output is some 50 per cent lignite so that in energy value, Great Britain outranks Germany.

In petroleum production, the output of the United States ranged around 63 to 65 per cent from 1910 to 1917, then rose to 69 to 73 per cent up to 1929 and has since dropped to about 62 per cent of the world's production. For 1933, the world production was 1,437 million barrels, an increase of 340 per cent over 1910.

In water power the United States for 1934 had 30 per cent of the world's installed kw. capacity, Canada some 13.4 per cent, Italy 11 per cent, Japan 8 per cent, France 7 per cent and Germany 5.9 per cent. Increase in water power for the United States has been 280 per cent from 1910 to 1933, the total for 1934 being 11.8 million kw. or 15.8 million hp.

Modernizing the Power Plant *for Profit*

By ARTHUR WALSH
Deputy Administrator,
Federal Housing Administration,
Washington, D. C.

MAJOR IMPROVEMENTS to the power plant ordinarily involve a capital outlay. Boilers and turbines and transformers are costly and frequently it is necessary for the board of directors to issue additional stock or bonds to pay for them. Often, for market or other reasons, this seems ill-advised. If the plant engineer is able to worry along with the old equipment, he is told to do so, even though substantial savings would result from a change.

Plant improvement is possible now on another basis. It may be accomplished without excessive cost on a monthly-payment program extending over a period which may be as long as 5 yr., the modernization credit plan of the Federal Housing Administration. If the plant engineer has been correct in his estimates, it is possible the savings it makes will pay the cost.

Money Provided by Local Bank

The system by which credit of this type is available is exceedingly simple in its manner of operation. The money is provided, NOT by the Federal Housing Administration, but by private financial institutions holding a Federal Housing Administration contract of insurance, such as banks, finance companies, trust companies and building and loan associations. The Federal Housing Administration insures the institutions against loss up to 20 per cent of the total amount any one of them loans under the plan.

Until recently the National Housing Act, from which the Federal Housing Administration derives its authority, limited to $2000 the amount of insured credit which could be extended to an individual, partnership or corporation. And, further, the money could be used only for permanent improvements to real estate. Congress, however, shortly before adjournment, enacted an amendment to the act increasing the limit to $50,000 and permitting it to be used, not only for real estate improvement, but also for the purchase of certain durable equipment listed as eligible by the Federal Housing Administration.

So it is that those concerned with the production and utilization of electric power have an opportunity of using the housing act for repair and modernization of buildings and for the purchase of equipment intended to bring their plants and distribution units into first-class shape. The opportunity is limited as to time, however. The modernization credit plan, under the law, is operative only until April 1, 1936.

The money in question may be used for virtually any improvement to the real estate. Buildings may be repaired or enlarged. Various facilities necessary to their operation may be installed, such as heating units, sprinkler systems, etc.

Definite principles apply to the character of the equipment that may be purchased with such a loan. The engineer and plant operator reviewing them will observe immediately, of course, that almost everything which is peculiarly adapted to production and distribution of power is covered by the regulations.

To begin with, the item of equipment should have a unit value sufficient to justify the application of time payments to its purchase. It should be of a durable nature with a reasonable expectancy of useful life longer than the term of the credit extended for its payment. It must be purchased and installed as a part of the equipment of a structure, or of the business conducted therein, within the United States or its territories and possessions. Hand-tools, small portable appliances, fragile articles, furniture (unless built in), furnishings, removable decorations and installations meant to be or by their character necessarily tempo-

rary are not eligible. Important to the power engineer is the fact that loans for the purchase and installation of replacement parts for eligible equipment and machinery are insurable, but a loan merely for the repair of a machine is not insurable. In this regard an example is cited: The cost of welding a flywheel cannot be the basis of an insured loan, but the purchase price and installation cost of a new flywheel would be insurable.

Turbines and rotors for turbines may be purchased with the credit. Generators and armatures similarly are purchasable. Governors may be bought as well as boilers, tubes, pumps, stokers and fuel conveyors. Boiler stacks may be built. Induced draft fans are eligible, as well as steam condenser equipment. The list also includes switchboards and rewiring. Where doubt exists as to elegibility a special ruling may be obtained by writing the Federal Housing Administration in Washington.

Quite independent of the plant generating electricity for distribution is one which is concerned merely with power for its own use. Such a plant has an opportunity to profit through the use of modernization credit. The installation of transformer or capacitor equipment may justify such a loan and permit its paying for itself through savings within a reasonable period of time. The engineer will know his problem and will be able to determine how modernization will save dollars for his plant.

Improvements Must Be Justified

Of course, the plant seeking modernization credit will ascertain in advance the improvements that seem justified and the cost. So fortified, negotiations with the lending institution are relatively simple. A formal application is made in which is set down the financial position of the prospective borrower and the period for which the credit is desired. As stated previously, the period may be as long as 5 yr., during which time the borrower makes monthly payments of equal size. The charge for the credit is a matter to be agreed on between the borrower and the financial institution. However, the charge will not be permitted to exceed the maximum rate established by the Federal Housing Administration. This rate is $5 discount per $100 face value of a one-year note payable in equal monthly installments.

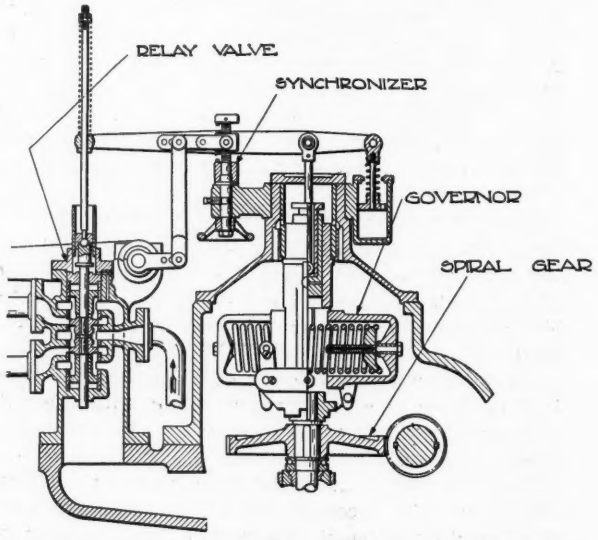
Electrical equipment of various types is purchasable, of course, on the installment plan, as is equipment of many other types. The rates ordinarily charged for credit uniformity are higher, however, than the maximum rates under the Federal Housing Administration plan.

Where credit so extended does not exceed $2000 it is necessary for the prospective borrower to submit to the lending institution evidence merely of his capacity to repay the loan and of his general reputation for meeting his obligations. Where the credit is in excess of $2000 the customary business principles apply. The lending institution probably will want to inquire fully into the details and the wisdom of the proposed improvements and may, at its discretion, require a mortgage or other form of security.

Steam Turbine Governor Regulation

In the article on turbine governor characteristics and regulation by William Welsh, Jr., of the Interborough Rapid Transit Co. (Part I, p. 494, September, 1935, Part II, p. 558, October, 1935) the illustrations were limited to two governors although the principles involved are applicable to other governors as well. Thinking that the actual constructional details of other governors would be of interest to engineers operating governors on turbines other than those mentioned previously we requested turbine drawings from the various manufacturers.

The governor of the Allis-Chalmers Mfg. Co. is adjusted for speed changes and range of speed variation for load changes similar to the two described in the main article. Its sensitive action is assured by a favorable connection between flyball weight and governor spring. By this arrangement the centrifugal forces of the weights act in line with the spring centerline



Flyball and relay valve arrangement of the Allis-Chalmers steam turbine governor

and do not produce pressure on pivots and link connections. This prevents frictional resistance interfering with the small governor movements and eliminates wear in the various pins.

Flyballs are driven by the main turbine through the shaft and spiral gear shown in the lower right hand corner of the drawing. The main governor spring is between the flyballs and the flyball motion is transmitted to the operating lever to the relay valve as shown. This lever is pivoted near the center, with the auxiliary spring at the left and a dash pot at the right. The synchronizer adjustment for speed changes during operation acts to change the height of the pivot point. Movement of the operating lever moves the pilot valve to admit oil pressure to the operating cylinder of the inlet valve (not shown) through the oil pipes running off the drawing at the left. Movement of the inlet valve is reflected back to the relay valve through the compensating lever shown above the oil pipes. The compensating lever moves to return the pilot valve to normal after changes in the inlet valve position.

ENGINES— Operation and Maintenance

Points That Experience in Operating Compressor Station Prime Movers Teaches Told to the Natural Gas Department of the A. G. A.

By B. L. ROGERS

Superintendent of Compressor Stations, Lone Star Gas Co.

EVOLUTION of main and connecting rod bearings for gas engines has been as eventful of late years as has the improvement of automobile engines. Ever since the World War superior bearing metals have been available at a reasonable cost, and the following general practices are among the noteworthy advances: The practice of tinning the shells, to flux the bearing metal firmly to the shell; complete absence of oil grooves, except one narrow one in the bottom shell directly under the axis of the shaft and perpendicular to the rotation, to insure a complete oil film quickly; slightly chamfering each shell on the edge opposing the rotation to speed up the establishment of the oil film; realization that 95 per cent of all lost bearings were hammered out rather than burned out, has brought about the practice of adjusting them extremely close.

In this connection it has long been general practice to tighten all main bearings while the engine is running, pulling the wedge tight, using a short handled wrench, relying upon the sense of touch rather than brute strength, and never backing off on the "wedge bolt." Also connecting rod bearings, should be tightened immediately after stopping the engine, while the running heat is still in the bearings and pins, pulling them perfectly snug, without any back off on the wedge bolt.

Frequent inspections are made of the main bearing adjustment by applying a "dial tester" reading in thousandths of an inch, by means of a rod extending through the inspection well in the top shell to the top of the shaft. This indicates the vertical movement of the shaft and a tolerance of 0.004 in. is the maximum permitted.

Since inaugurating these practices many plants of ours have gone for several years (1) without the loss of a bearing; (2) without the loss of a foundation bolt; (3) without the necessity to regrout an engine; (4) without a noticeable longitudinal vibration of foundation blocks.

Importance of Ring Fit Realized

Various ingenious and practical methods of building tension into piston rings have been developed, but how often is a new bore of precisely the diameter for which the ring was made? In many makes of large engines a wide tolerance is found and no two sets of rings will fit the respective bores exactly alike. Again stock rings do not often closely fit the cylinder, which we find to be of a slightly different diameter than we anticipated when ordering rings. When a cylinder which is to be fitted with new rings is taken down, the horizontal and vertical micrometer measurements are rarely found to be exactly alike.

A simple means has been found of remedying this difficulty and assuring a perfect fit within 0.002 in. at all points on the ring circumference, regardless of whether a bore is round or slightly elliptical. This simple means consists of peaning the ring lightly but firmly with a small, soft brass, ball pean hammer, or by means of a peaning tool. This method is illustrated by simple sketches.

Assume that snap ring in Fig. 1 is placed in the bore with the gap in ring being in the position in which it will be when piston is in place and that the portions a-b and c-d of the ring do not touch the bore by 0.010 in. to 0.105 in. at a point mid-way between a and b and mid-way between c and d.

Locate a on the ring as the first point at which the ring leaves the bore by 0.002 in. and mark the point on ring with chalk. Also locate b on the ring as the last point to which a 0.002 in. feeler will swing between ring and the bore and mark this with chalk. Locate points c and d in the same way and mark with chalk.

Peaning with Hammer

Then using for a mandrel any machined surface, which has a diameter reasonably close to the inside diameter of the ring, place the ring over this mandrel and locating the approximate midpoint between a and b on the ring, and marking with chalk, hold the ring squarely on the mandrel and pean lightly but firmly, with either a light weight, soft brass, ball pean hammer or a peaning tool, for a distance usually about half the distance toward a from the midpoint and toward b from the midpoint.

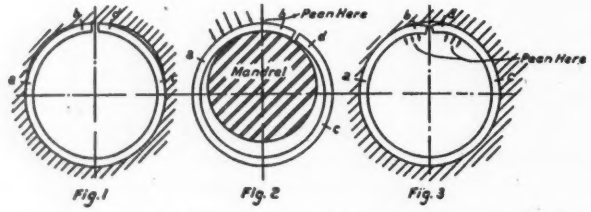
Turning the ring slightly on the mandrel so that the blow will strike directly in line with the common vertical centerline of the mandrel and the ring and lightening the blows slightly as the point struck approaches a and b, respectively. The number and weight of the blows necessary can quickly be determined, but at first the ring will have to be tried in the bore repeatedly to note progress. Most operators quickly become expert if careful at first. Figure 3

shows the same ring in the bore after a-b and c-d have been peaned until all points between a and b and between c and d come within 0.002 in. of contact with the bore.

But since the effect of the peaning process, to accomplish this, was to stretch the outer surface of the ring between a and b with reference to the inner surface between the same points, we find the outer surface of the ring from b to the gap, now curls in away from the bore as shown (exaggerated in Fig. 3).

It is now a simple matter to leave the ring in the bore and lightly pean the inner surface starting to the left of b and moving slowly toward the gap, and to the right of d and moving toward the gap, until those short ring ends have been laid back against the cylinder bore within the desired tolerance.

It is obvious that each ring must be peaned in the exact position in which its gap will be placed on the piston, and the piston turned in exact position planned. Then having no more than 0.002 in. clearance between ring surface and cylinder wall at any point, a perfect ring fit may be assured (assuming the surface of the ring is not finished extremely smooth) even before the idling limbering up period is complete.



Figs. 1-3. Details showing method of fitting piston rings by careful peaning

In many instances where the foregoing practice was not used, pistons have never been without a marked blow-by and a complete oil film never established within the life of the set of rings. But assuming due diligence has been exercised in fitting rings as above described, we are firmly of the belief that if ever rings are found stuck in the groove, groove and butt clearance being in line, it may be traced to either too much oil delivered to the rings or water has leaked into the cylinder.

Lubrication and Lubricating Oils

Selection of lubricating oils is of vital importance. Some years ago we awakened to a realization of the fact that 58 different oils were in use in our compressor stations, and that horsepower hours per gallon showed a wide range of difference. Since that time, by carefully studying the records of each oil as to economy versus maintenance cost, all but five of the original 58 have been gradually eliminated, with constantly increasing horsepower hours per gallon and consistently reducing maintenance costs.

Some few plants had been using a single oil for both cylinder lubrication and circulating oil. None of these exceeded the average economy for all plants. Examination of the disbursement of oil in each of these one oil plants indicated that in each case the oil used was much better suited to one purpose than the other.

The first step was to stop the use in the circulating system of oils which the records showed best suited for use in lubricators, and vice versa, and to substitute an oil which had a record among the best, for the purpose desired. This examination of records also showed some plants where two oils were used, had been using one of them for one purpose, when it was better suited for the other. Thus the elimination of oils proceeded and we now know the remaining oils in use are adapted to the purpose for which they are purchased.

Concrete results of this experience resulted in these firm convictions: Use of an oil for cylinder lubrication in a gas engine which has a Saybolt viscosity of less than 57 sec. at 210 deg. F. is false economy; use of an oil for that purpose, having a Saybolt viscosity of more than 75 sec. at 210 deg. F. is extravagant and cannot justify the price per gallon; an oil of viscosity ranging between 57 and 75 sec. at 210 deg. F. "flash" and "fire test" and "carbon content" being in line, can be depended upon to give 15,000 b.hp. hr. per gal., when lubricating both power and compressor cylinders and power and compressor rods, with lower maintenance expense than will result from more lavish use of oil; if above figures cannot be attained, the reason is to be found in some faulty mechanical condition, such as ring fit, ring clearance (either end or groove clearance) faulty alignment of piston or failure of force feed lubricator to deliver uniformly.

We find the following ring clearances necessary for four-cycle gas engines: Groove clearance, No. 1, 0.008 to 0.010 in., No. 2, 0.006 to 0.008 in., No. 3, 0.004 to 0.006 in., No. 4, 0.004 in.; butt clearance in inches per inch of diameter, No. 1, 0.006 to 0.008 in., No. 2, 0.005 in., No. 3, 0.004 in., No. 4, 0.004 in.

The use of miter cut snap rings has been discontinued. Ring No. 3 is step out and rings Nos. 1, 2 and 4 are square cut.

Circulating Oils

Circulating oils need not have a viscosity of more than 150 sec. (Saybolt) at 100 deg. F. since bearings are kept very tight. Usually thoroughly dewaxed paraffin oils are preferable as they circulate more freely at the lowest anticipated engine room temperature, and are more easily cleaned, do not emulsify as readily, and have higher demulsibility. They also distribute more readily and replenish the lubricating film promptly.

Since the circulating oil, unlike the force feed oil, is used over and over many times, when the circulating system at any plant fails to show satisfactory service per gallon, a "Stop the Leak Campaign" is in order. Such a campaign means the careful going over of the following probable leakage sources: Careless measurement and handling; porous castings, pipe or fittings; crankcase leaks due to improper gaskets and unnecessary splashing; oil wiper rings to prevent crankcase oil being carried into compressor or power rod packing; excessive gallonage may be carried out daily in the wiping rags. An excellent method of locating such oil losses is to refrain from wiping up waste oil until the exact source of the loss is determined and necessary steps taken to prevent recurrence of loss.

Having found that an oil suitable for cylinder lubrication was entirely unsuited for bearing lubrication as

well as uneconomical, and that a good circulating oil could not properly lubricate the power cylinders and increased maintenance cost more than offset any saving due to lower price per gallon, we venture the following conclusion:

That an oil, in order to serve both purposes satisfactorily, would have to combine the characteristics of a 30 S.A.E. rating at 210 deg. F., with those of a 10 S.A.E. rating at 100 deg. F. No such oil was heard of until very recently. Oils having such a low viscosity index, so flat a temperature viscosity curve, have only recently been sponsored by research laboratories and made commercially available, but at a premium price per gallon.

Necessity for Scale-Free Water

It has now become uniformly recognized that water having a hardness of more than three grains per gallon should be reduced by some means to less than that figure in order to keep the machinery scale-free. Some waters, of course, can only be treated chemically at a prohibitive cost, in which case, an enclosed system, or as close an approximation thereto as is possible, should be installed. In this connection, water which has been successfully treated with zeolite, or distilled water to which is added a corrosion inhibitor, whichever can be provided with the least expense, should be used for makeup purposes.

Oklahoma Ice Plant Modernized

Crystal Ice & Cold Storage Co., Bartlesville, Okla., Rebuilds Plant

AFTER 32 yr. of progressive ice production, the Crystal Ice & Cold Storage Co. at Bartlesville, Okla., last year completely rejuvenated their plant. Automatic controls, two of the newest type vertical gas engines; latest type ammonia compressors; new trunk type freezing system; new automatic water softener and purifying plant; new four-can ice-harvesting hoist; new automatic ice-can filler; new scoring machine; new air compressors and dehydrators—in fact, everything necessary to make ice production modern and efficient was installed.

In 1903 when Bartlesville was little more than a trading post, Harry H. McClintock opened his first 10 t. ice plant. The plant thrived from the beginning. In 1906 a tank was added to the plant, and a flooded system was installed two years later. A freezing tank and a larger ice machine were included in the improvements made during 1911. The old brick storage plant was constructed in 1912, and in 1914 the plant expanded to Dewey, where a branch was installed. During 1917 and 1918 the present ice-storage and office buildings were erected and another freezing tank added to take care of the increasing volume of business. The latest installation began in October, 1934, after four years of investigation, planning and research.

Two Cooper-Bessemer Type 14 gas engines, one a 4-cylinder 180-hp. engine, the other a 3-cylinder 135-hp. engine, are direct connected through flexible couplings to two York ammonia compressors with a capacity of 50 t. at 18 deg. F. The engines also drive, with V-belts, two 50-kw. Electric Machinery generators.

Raw water used in manufacturing ice at the plant is often so bad that distilled water must be mixed with it to bring the grains per gallon of chlorides and sulphates down to a point where merchantable ice can be made. So, when the two vertical gas engines were installed, the steam boilers formerly used were retained for the purpose of distilling the water. One of them, a fire-tube boiler, was converted into a muffler for the gas engines, the exhaust lines being carried through the floor of the engine room into a pipe gallery. This boiler is kept full of water, which is preheated by the exhaust heat, then pumped into one of the other boilers where it is evaporated. The steam is then condensed into distilled water for use in manufacture of the ice.

Storage Battery Charging

We direct attention to an error in Part II of the article "Storage Battery Charging" which appeared on page 561 of the October issue. In the heading of this article, the author's professional connection should have been listed as The Electric Storage Battery Co., Philadelphia, instead of that listed. It was given correctly in Part I of the article on page 515 of the September issue.

Two Loeffler boilers designed for 210,000 lb. of steam per hr. at 1900 lb. pressure, total temperature of 930 deg. F., are being built in England by the Mitchell Engineering, Ltd., for the Brimsdown "A" Power Station at North London, England.

Fig. 1. Turbine room as rebuilt. The rebuilt unit is in left foreground

Annapolis

U. S. Naval Academy Replaces Old Boilers with New Ones and Installs a.c. Generating Equipment

BUILDING A POWER PLANT is a formidable task; rebuilding an old plant under the most favorable conditions is a greater task due to limitations placed on design by existing space and equipment requirements, but rebuilding an old plant in limited time while maintaining full and uninterrupted service is an accomplishment that tests to the utmost an engineer's skill and ingenuity. That it can be carried through successfully, however, is shown by the completion of the new power plant at the U. S. Naval Academy at Annapolis. This work, one of the early P.W.A. projects under the Bureau of Yards and Docks, Navy Department, was carried through under the supervision of Lieutenant Commander T. A. Hartung (CEC), U.S.N., Officer in Charge of Public Works Contracts at Annapolis. Seven public works contracts were entered into by the Bureau of Yards and Docks for the different portions of the work.

In the boiler room four new 400 lb., 50,000 lb. per hr. oil fired boilers replaced eleven old 400 hp., 160 lb. coal fired boilers and in the turbine room several new A.C. units and transformers were added, and D.C. units changed or scrapped, to take care of the increasing power load of the Academy. Originally the main electrical system was 110/220 v. d.c., but this was changed to a.c. and a complete new a.c. distributing system with ten transformer stations was installed in order to better fit in with contemporary power advances. The new plant has four steam pressure levels: 375 lb., 150 deg. F. superheat for power generation; 135 lb. for auxiliary drives and heating; 35 lb. for heating, and 6 lb. auxiliary exhaust for feedwater heating. Normally the three lower pressure systems are supplied from extraction or exhaust steam but for emergency operation are tied together through reducing valves (with a desuperheater between the 375 and 135 lb. levels).

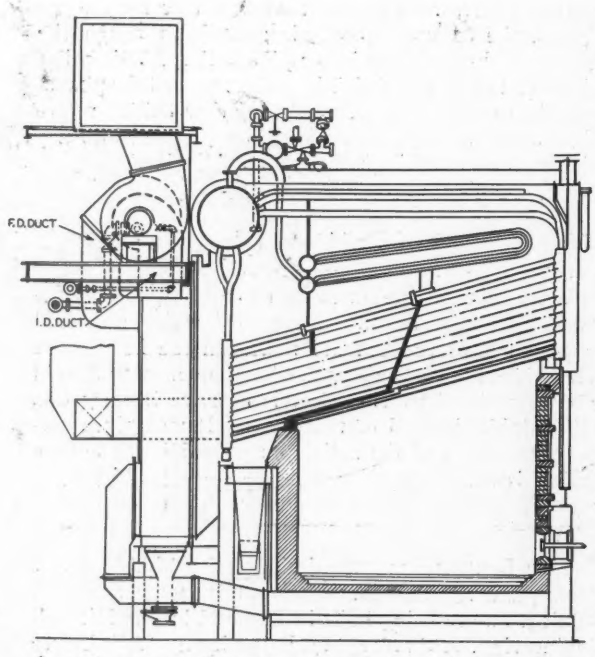


Fig. 2. Section through the boiler

Previous to the change the main electrical equipment consisted of: one 1000 kw. d.c. unit; one 750 kw. d.c. unit; one 500 kw. engine-driven d.c. unit; one 300 kw. d.c. unit; one 125 kw. a.c. unit and one 150 kw. d.c. to a.c. motor generator set. The first step in the building program was to install the oil tanks, two new boilers, a 500 kw., 375 lb. 150 deg. F. superheat, a.c. unit, and to convert the 300 kw. d.c. unit to an a.c. to d.c. motor generator set by replacing the turbine with a 450 hp. synchronous motor, thus permitting a start on converting the load from d.c. to a.c. throughout the Academy. A new 1000 kw., 375 lb., 150 deg. F. superheat a.c. unit was then added. This unit, shown in the right foreground of Fig. 1, consists of a 3600 r.p.m. condensing turbine designed for extraction at 135 lb. and driving a 1000 kw., 2300 v. generator and direct connected exciter. This unit is set over a 2000 sq. ft. surface condenser. The next unit added, visible in the left background of Fig. 1, consists of a 3600 r.p.m. turbine exhausting at 135 lb. and driving a 500 kw., 2300 v. a.c. generator and direct connected exciter. A steam driven exciter, in front of the stairs in Fig. 1, was also added. This is a 125 v., 25 kw. exciter driven by a 37.5 hp. turbine which like all the steam auxiliaries, takes steam at 135 lb. and exhausts to the 6 lb. system.

The 500 kw. engine driven unit and the 750 kw. d.c. unit were scrapped, the 150 kw. d.c. to a.c. motor

Modernizes Power Plant

generating set was rebuilt for a.c. to d.c. service; and the 1000 kw. turbine was rebuilt for 375 lb., 150 deg. F. superheat with extraction at 35 lb., and reset over the original 2500 sq. ft. surface condenser. The d.c. generator for this unit was replaced by a new 1000 kw., 2300 v. a.c. generator. This gives in the rebuilt plant, two 1000 kw., and one 500 kw. in a.c. generating capacity; one 300 kw. and one 150 kw. a.c. to d.c. motor generating sets, a combination sufficiently flexible to take care of the steam demands at various pressures with the maximum power output. The main

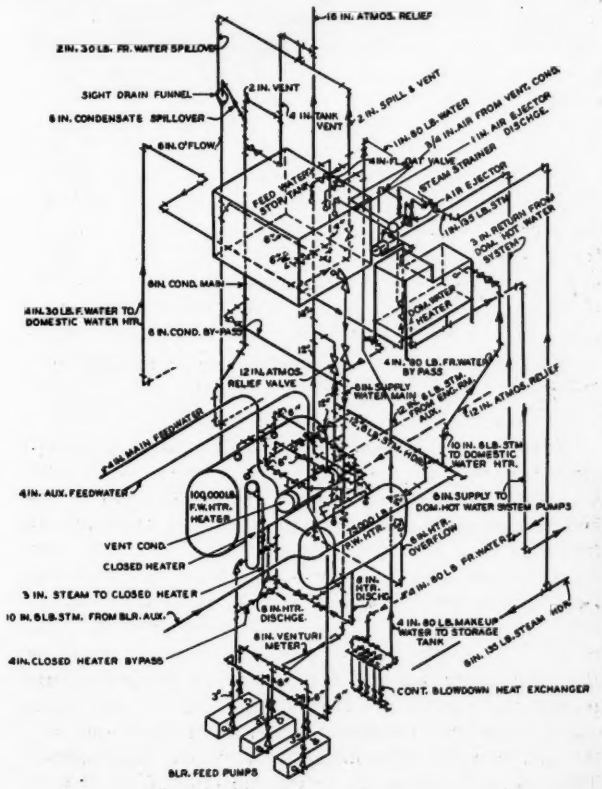

16 IN. ATMOS. RELIEF
2 IN. 30 LB. FR. WATER SPILLOVER
SIGHT DRAIN FUNNEL
2 IN. VENT
6 IN. CONDENSATE SPILLOVER
6 IN. TANK VENT
2 IN. SPILL & VENT
1 IN. 80 LB. WATER
3/4 IN. AIR FROM VENT. COND.
1 IN. AIR EJECTOR DISCHGE.
6 IN. O'FLOW
4 IN. FLOAT VALVE
STEAM STRAINER
AIR EJECTOR
FEED WATER STORAGE TANK
1 IN. 135 LB. STM
3 IN. RETURN FROM DOM. HOT WATER SYSTEM
6 IN. COND. MAIN
DOM. WATER HEATER
4 IN. 30 LB. F. WATER TO DOMESTIC WATER HTR.
6 IN. COND. BY-PASS
4 IN. 80 LB. FR. WATER BY PASS
12 IN. ATMOS. RELIEF VALVE
8 IN. SUPPLY WATER MAIN
8 IN. 61 LB. STM FROM BAC. HDR. AUX.
12 IN. ATMOS. RELIEF
24 IN. MAIN FEEDWATER
10 IN. 61 LB. STM TO DOMESTIC WATER HTR.
4 IN. AUX. FEEDWATER
100,000 LB. F.W. HTR. HEATER
8 IN. SUPPLY TO DOM. HOT WATER SYSTEM PUMPS
75,000 LB. F.W. HTR.
8 IN. HTR. OVERFLOW
VENT COND.
CLOSED HEATER
3 IN. STEAM TO CLOSED HEATER
24 IN. 80 LB. FR. WATER
10 IN. 61 LB. STM. FROM BLR. AUX.
8 IN. HTR. DISCHGE.
8 IN. HTR. DISCHG.
6 IN. VENTURI METER
4 IN. 80 LB. MAKE-UP WATER TO STORAGE TANK
8 IN. 135 LB. STEAM HDR.
4 IN. CLOSED HEATER BYPASS
CONT. BLOWDOWN HEAT EXCHANGER
BLR. FEED PUMPS

Fig. 3. Isometric drawing of the feedwater heaters and boiler feed pump piping

switchboard consists of 18 panels with necessary instruments including a voltage regulator and a synchroscope.

In the boiler room practically all old equipment was removed, only one deaerating feedwater heater being retained. Of the 11 old boilers, eight were removed to make room for the four new boilers. These units were put in two at a time, each set replacing four of the old ones. The remaining three old boilers, which were disconnected, will be removed later to make room for another new boiler when needed.

These new units are 5802 sq. ft., 400 lb. pressure, 150 deg. F. superheat straight tube boilers with air cooled walls, and fired by a wide range oil burning system. Each boiler has 1446 sq. ft. of convection superheater, a 6430 sq. ft. plate type preheater and forced and induced draft fans. Both fans are dual driven as a unit by a 50 hp. motor through hydraulic coupling drives and a 47 hp. turbine through a reduction gear. The induced draft fan has a capacity of 20,650 c.f.m. at a static pressure of 2.5 in., and the forced draft fan 13,700 c.f.m. of air against a static pressure of 6.5 in. All boilers are controlled by an automatic combustion control system. Fuel oil is stored in 15,000 bbl. concrete tanks and pumped through oil heaters to the boilers. The oil temperature is controlled manually. Each boiler has three burners.

Well water taken from the Yard system is treated with lime and zeolite and used for feedwater makeup. This water is stored in a tank above the two deaerating heaters, details of the heater and feed pump piping being shown by the isometric drawing, Fig. 3. Three boiler feed pumps, two driven by turbines and one by a motor, are installed, the motor-driven one rated at 50,000 and the two turbine-driven ones at 120,000 lb. per hr. These pumps are equipped with pump governors. The feed pumps and oil heaters are installed in a central location between Nos. 3 and 4 boilers.

Fig. 4. Two of the new oil fired boilers

High Voltage Condenser Welding

Novel method of welding utilizing high voltage condenser discharge developed at the Svetlana Works Research Laboratory, U. S. S. R. While only in the laboratory stage it offers possibilities in certain branches of the welding field. It is capable of delivering energy to the welds in intervals as short as 1/10,000 sec.

Fig. 2. Discharge tube

SPOT WELDING has been known for more than 30 yr. In all the existing types of machines for spot welding, the welding transformer is supplied from standard single phase 50 or 60 cycle alternating current mains, as was done from the time the process was first developed.

To improve the quality of certain welds it was necessary to cut the duration of the welding current for each spot, and the welding time as short as possible. This resulted in the development of different complex mechanical contactors. Recently with the increase in industrial application of electronic devices some advances have been made in resistance welding by the use of the thyratron or other similar forms of electronic control.

In practice the shortest welding time obtainable is ¼ of a cycle, that is, the shortest welding time may be 0.01 sec.

Furthermore, the mechanical contactors as well as the thyratron controllers control only the welding time, not the energy delivered to each spot. The ordinary welding machine ordinarily does not operate at much less than 10 to 20 cycles for each spot, that is, about 0.2 to 0.5 sec.

In order to limit the welding time to intervals of from 1/1000 to 1/10,000 sec. and in order to control exactly the amount of energy delivered to each welded spot, it is necessary to abandon the low frequency alternating current source of power supply and investigate other methods.

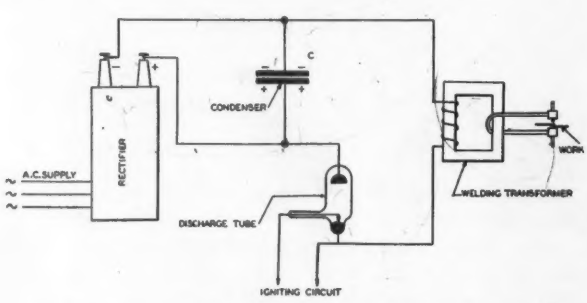


Fig. 1. Schematic diagram of the circuit of high voltage condenser welding

The method described here was presented in an article in The Welding Journal of the American Welding Society,[1] by Engineer G. I. Babat of the Research Laboratory of the Svetlana Works, U. S. S. R. It is known as the High Voltage Condenser Method.

The principle involved in this method is quite simple and may be understood from the diagram in Fig. 1. The condenser C is charged to a high potential by a rectifier supplied from the a.c. mains. If the condenser capacity is C microfarads and it is charged with V volts, the electrical energy stored in it in joules (watt seconds) may be expressed by the classic formula:

$$W = \frac{CV^2}{2}$$

The condenser having a capacity of several microfarads and charged to from 3 to 5 kv. can store several hundred watt seconds while, according to experiments for welding stainless steel with a thickness of 0.25 mm., it is necessary to expend only 20 to 30 watt seconds.

As may be noticed from the circuit diagram, the system presents nothing unusual but the welding transformer is of special construction. The secondary of this transformer consists of a single turn and is connected to the electrodes between which the material to be welded is pressed.

The charge stored in the condenser C passes through the primary winding of the transformer under the control of a special discharge tube. This discharge tube is shown in Fig. 2. It is a mercury vapor tube with a special igniter.

Such a discharge tube is capable of passing im-

[1] August, 1935, issue.

pulses of short duration of the order of several hundred amperes. When the condenser discharges through the welding transformer primary, a current, exceeding some hundred times the current of the primary, is induced in the secondary.

With the proper design of welding transformer, it is possible to obtain results showing that more than

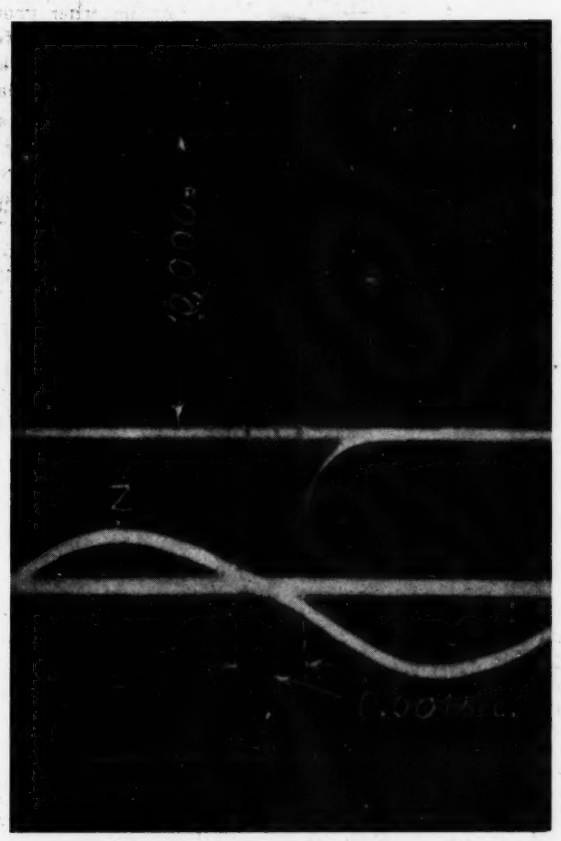


Fig. 3. Oscillogram showing transformer currents. The upper curve is the welding current. The lower curve is the current in the primary curve Z in the 50-cycle voltage and is shown here for comparison

90 per cent of the energy stored in the condeser is delivered at the welded spot. Fig. 3 shows an oscillogram of the welding transformer currents. The upper curve is the current in the primary. The lower curve is the welding current delivered at the secondary winding.

The duration of the current impulse through the transformer secondary is determined by the condenser capacity and by the magnitude of the leakage inductance of the transformer. With proper construction of the welding transformer it is possible to decrease the transformer leakage reactance in such a way that it may become possible to obtain a duration of less than 1/10,000 sec.

It is quite easy to regulate the inductance in the welding transformer circuit and thus to fix any welding time required.

Since the duration of the welding current is extremely short, the secondary voltage of the transformer in this welding system is much higher than that used in the ordinary type of welding machine. This is necessary in order to deliver the required quantity of energy at the welded spot. In the ordinary welding transformer the amplitude of the secondary voltage does not exceed a few volts. But with the method described here the amplitude of the secondary voltage of the welding transformer may be of the order of 20 to 100 v.

The quantity of energy consumed by every welded spot may be conveniently controlled by varying either the condenser capacity or the voltage up to which it is charged. It is possible, for example, to connect a voltmeter in parallel with the condenser and to calibrate it directly in watts.

While this method of producing welds by means of a condenser discharge is not new, all earlier attempts were based upon the application of condensers at low voltage, that is, the discharge current of a condenser was delivered directly to the welding spot without the use of any intermediate transformer.

Since the quantity of energy stored in the condenser is proportional to the square of the voltage on its plates, it is obvious that in order to store an appreciable quantity of energy in a low voltage condenser, it is necessary to have a condenser rated at hundreds or even thousands of microfarads. This fact made the low voltage condenser welding method quite limited even when using electrolytic condensers.

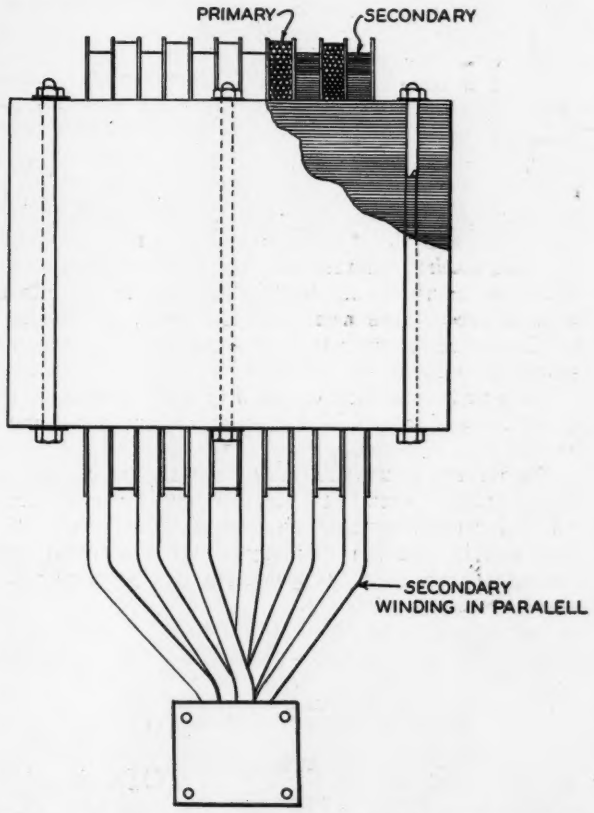


Fig. 4. Schematic drawing of the shell type of transformer used

The principal advantages of the high voltage method of welding can be summarized as follows:

(A) The quantity of energy delivered to each welded spot is controlled with an accuracy unobtainable by any other method. (B) The welding time is subject to simple and definite regulation and it may be

extremely short, as short as 1/10,000 sec. Thus, for any kind of material to be welded, it is possible to choose the most suitable thermal condition. (C) The load on the alternating current system is uniform and produces no violent swings in voltage. Though the instantaneous power developed by this welding apparatus at the moment of the condenser discharge is rather high (several hundred kw.) it is not obtained from the a.c. mains as in the case of the usual welding apparatus but is delivered by the condenser which stores the necessary quantity of energy during the interval between two successive weldings. Since the absolute quantity of energy consumed by each welded spot is not very high the average power consumed by the apparatus is rather low. (D) The method of high voltage condenser welding may be applied with success not only to spot welding, but also to line welding. For line welding a sufficiently powerful rectifier should be used in order to obtain the required speed in charging the condenser. The rollers are connected to the welding transformer secondary and the welded material is then passed between these rollers. The welding transformer used in the system is of the shell type, its primary consisting of separate well insulated sections. All the primary sections are connected in series. The secondary consists of 6 separate turns placed between each section of the primary and these are connected in parallel. Each turn of secondary consists of a set of thin copper wires. The winding electrodes are connected to the ends of the secondary winding. The apparatus described here was constructed for use only in the laboratory. By means of it they have welded stainless steel (18 per cent Cr, 8 per cent Ni). The thickness of the sheet was 0.1 to 0.6 mm. The total thickness of the welded sheets was up to 1.5 mm. The condenser capacity was 10 mf.

The mechanical properties and general appearance of the welds produced by this method are superior to welds made by other methods of control. Light alloys —duraluminum and superduraluminum have been successfully welded by this equipment. A possible application of this method of welding is in aeroplane construction. The method has special advantages for repairing all metal aeroplanes as it may be used in places where there is no powerful electric supply. Indeed the condenser used in this system may be charged from a motor car magneto, the only disadvantage of this method is that the charging will be produced very slowly and the intervals between two separate welds will be of long duration.

Specifications and the Engineering Profession*

SOME one once defined an engineer as "a person who does things with things." This definition is neither sufficiently inclusive nor properly exclusive, but it does have a certain value for my immediate purpose. It does emphasize the engineer's tremendous and vital concern with "things." It is true that he is equally concerned with people and with energies and with other factors but his work can never be divorced from what may be designated by the homely name "things." These things may be nothing more than sand or clay or a simple piece of metal; or they may be most complicated assemblies, stationary on the earth's surface or moving with gigantic rhythms of their own. In all cases, whether simple or complex, they consist in ultimate analysis of what we call materials.

In one sense, the development of engineering has rested solidly upon the acquisition of knowledge regarding materials. There is probably no other group that uses so many different materials in so many different ways as does the engineer. And the number available to and used by him increases almost day by day.

In all cases a material is used because of certain properties or characteristics; in some cases in spite of some of them. In either event a knowledge of properties and characteristics is absolutely essential to success. The practice of engineering is based upon the choice and use of just those materials adapted to produce the desired technical and economic results.

Weakness Lies in Method of Getting Data

As I see our situation, our great weakness at present lies in our lack of a more orderly procedure for uncovering the fundamental knowledge required. In all too many cases we are dependent upon the more or less accidental interest of some lone experimenter in some particular problem. In all too few instances do we organize a collective and comprehensive attack upon a given piece of territory. This usually occurs only after we have found ourselves in such hot water that we have our choice between finding hastily a ladder out of the pool or remaining to be boiled. And no one really relishes being boiled.

I might cite as an example of orderly procedure the recent international investigation of the properties of water and steam. A few comparatively inexpensive laboratory investigations, carefully planned and well correlated, served to bring order out of something approaching chaos. Now we have such an exact and extended knowledge of the thermal and certain other properties of these important engineering materials that we may regard the story as closed for some time in a practical engineering sense.

In contrast to such situations we have the tremendous number of cases in which phenomena which would yield readily to comparatively simple mass attack are still just as much the subject of debate as they were five or ten or twenty-five years ago. I think the day of that sort of thing should be behind us. Unfortunately it is not. But that is no reason why we should not prepare to put it behind us as rapidly as possible.

Specifications and practical engineering are so closely associated, in fact so indissolubly bonded, that the practice of engineering without specification is a practical impossibility. Present available specifications still lack in numerous cases that specificity without which they are only most imperfect tools and a greater extent of knowledge must underlie any real attempts to improve such specifications.

*Abstracts from an address presented at the annual meeting of the A. S. T. M. by C. F. Hirshfeld, Chief of Research Department, the Detroit Edison Co.

Factory Built Cubicles *Save* Time and Space

By ROBERT T. McKINNEY
Panelboard Specialist
Westinghouse Electric & Mfg. Co.

EFFICIENT industrial plants of today employ many separate units in the conversion of electrical energy into mechanical motion. Individual tool drive at first presented an added problem in electrical distribution, and scattered drive units suggested scattered control units. The demand for further economies in plant construction, operation, and maintenance, resulted in the concentration of control and distribution elements in structures—located at convenient load centers. This grouping of the motor circuit control and protective devices is now further justified by the development and successful application of the factory built, "Nofuze," distribution and control cubicle.

The essential protective and control elements of a motor circuit may be listed as follows:

1. Motor branch circuit protective device. (A circuit breaker or fuses.)
2. Disconnecting means. (A motor circuit switch.)
3. Motor running protective device. (A thermal overload relay.)
4. Controller. (A magnetic contactor and push button station.)

The usual location of the motor branch circuit protective device is in the distribution panel. The other three devices are located separately or together in locations suitable to the machine and the process.

Scattered Location of Units

If the motor circuit switch, overload, relay, and magnetic contactor are all located at the machine near the push button station, the maintenance crew is forced to travel about the plant carting tools, testing equipment or renewal parts. It is impossible to locate maintenance equipment and supplies close to more than one or two machines. Consequently the work of trouble location, performance tests, and repair, takes considerable time and production delays are prolonged. Since the switch and starter must be mounted where they can be safely manipulated and inspected, considerable valuable space must be reserved around them. The extra conduit work around and on the machine increases the installation costs and makes the machine much harder to keep clean. Where conditions are hazardous, or where the equipment is exposed to water and chemicals, the devices must be enclosed in special cabinets approved for the class of service.

It is possible to group the motor circuit elements at the plant load centers leaving the push buttons located at carefully chosen control points near the machines. In such an installation the motor circuit protective device and the motor circuit switch are combined in a single circuit breaker or fusible safety switch. Light steel frames, bus gutters, and wiring gutters are used to facilitate the field assembly work.

This arrangement allows complete tests and repairs to be conducted on any number of circuits without the extensive and frequent transportation of maintenance apparatus. Production delays are naturally reduced to a minimum as are maintenance costs. The machines are relieved of a great deal of auxiliary conduit. Where the equipment might be exposed to water and chemicals or where the conditions are hazardous the load center is easily protected by location in a separate room.

The assembly of separate unit cabinets presents many difficulties in spite of the mentioned advantages. It involves just as much conduit work and connecting as the scattered unit method. If larger motors are installed on the existing circuits it is difficult to change the switch and contactor due to the conduit work involved. The space required for the structure is little less than the total space required for the feeder elements in the scattered arrangement. A clean uniform appearance has not been completely attained. Where it is necessary to interlock the control of several motors, as in conveyor installations, considerable additional conduit work is necessary. Where the common wiring gutter is used trouble on one feeder may be

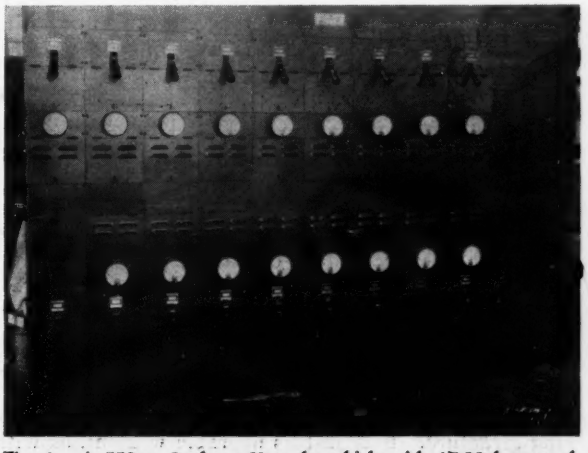


Fig. 1. A 550 v. 3 phase 60 cycle cubicle with 17-30 hp. standardized distribution and control sections each equipped with back of board fusible switch line-starter, and self contained ammeter.

Fig. 2. View of the "Nofuze" cubicle. Wiring and maintenance is facilitated by side hinged doors and generous working space around each contactor.

communicated to all the wires in the gutter thus paralyzing a considerable portion of the plant.

With a keen realization of the inadequacy of field assembly of the distribution center with gutters and conduits, switchgear engineers created the factory built sectional steel cubicle (Fig. 1). In this form the motor circuit elements are fundamentally the same. The cubicle consists of a rigid structural steel frame supporting sheet steel front and rear plates and with the interior divided into compartments by steel barriers. Each motor circuit is isolated from every other, from the point of connection at the main bus to the conduit leading to the motor. Each switch and contactor is enclosed in a separate steel section. Connections between bus and switch and between switch and starter must pass through restricted passages. Interlocking of controls may also be obtained through the use of additional restricted passages between compartments. Common wiring gutters are avoided. Trouble in one section cannot be communicated to the other sections.

Sometimes the equipment in each section is installed to suit the highest possible section rating, but in any event, the change in rating of any feeder within limits entails almost no additional cost at the distribution center. As all parts are standardized, any number of additional feeders may be conveniently added without destroying the uniformity of the group.

The Application of Automatic Circuit Breakers

By restricting the motor circuit switch and the protective device to Nofuze Deion circuit breakers it is possible to construct a cubicle with many added advantages (Fig. 2). Due to the unusually small size of this breaker the feeders can be grouped four high for 1 to 30 hp. sections and two to three high for 30 to 60 hp. sections. Removal of four screws in the steel cover over the breaker dismounts the door over the contactor compartment and one feeder section is completely exposed. The breaker is incased in moulded composition and is entirely independent of the enclosing structure. It is just as operable without, as with, the steel section cover, so that tests and repairs may be made on the starter with great facility. A spring hinged cover over each breaker makes it possible to lock any circuit open when safety dictates.

Perfect circuit protection is obtained as the circuit breaker discriminates between dangerous overload and short time peaks. The Nofuze cubicle therefore requires almost no attention and eliminates many of the unnecessary production delays. When the breaker trips it is a sure sign of trouble worth investigation, but when the trouble has been cleared service is quickly restored by a flip of the breaker handle. If an attempt is made to close in on a faulty circuit the breaker trips again in spite of the position of the handle. This is due to the trip free feature. Single phase operation with polyphase motors, so possible with an independent overload element on each phase, is well nigh impossible with the breaker, as a dangerous overload on any phase trips all poles of the breaker simultaneously.

It is interesting to compare the wall area required for the motor circuit switch and starter in the various methods of arrangement described above. As a basis for comparison we will choose the standard equipment required to control a 30 hp. three phase 440 v. 60 cycle squirrel cage motor with across the line starting.

Average Well Area Comparison

A. Scattered or machine mounted.....7.6 sq. ft.
B. Bus gutter and unit cabinet assembly.....7.0 sq.ft.
C. Fusible factory built cubicle.....4.3 sq. ft.
D. Nofuze factory built cubicle.....3.0 sq. ft.

The time required to install the various arrangements may be compared on the basis of field operations thus:

Methods A. & B.	Methods C. & D.
Prepare mounting frame.	None.
Set up frame work.	Set up cubicle.
Mount distribution box, switches, and starters.	None.
Install main conduit.	Same.
Connect main feeder to main bus.	Same.
Install conduits between dist'n. box or bus gutter & switches.	None.
Install conduits between switches and linestarters.	None.
Connect from main bus to switch,	None.
Connect from switch to linestarter.	None.
Install conduit from linestarter to motor and pushbutton.	Same.
Connect linestarter to motor and pushbutton.	Same.
Install conduit between units for interlocking control.	None.
Connect between units for interlocking control.	Jumpers between compartments.

A total of 13 operations are listed here, six of which are common to all four types of installation. Several field operations eliminated by the cubicles represent a great deal more time saved than a mere tabulation of operations indicates.

The Nofuze cubicle presents all the advantages of centralized distribution and control with added insurance for uninterrupted production schedules. It reduces by 50 per cent the time required to install the distribution and control elements. It requires 50 per cent less space than field assemblies.

Possibilities of Pulverizers for Small Boilers

Developments in This Field Reviewed for the A. S. M. E. at Cincinnati Convention. By James W. Armour, Riley Stoker Corp.

USE OF PULVERIZED FUEL as a method of burning coal is a rather long established art, yet it is only in the last few years that it has made rather definite, forward strides. Today there is no question about the standing of pulverized fuel for use with steam generators of capacities of 500 b. hp. and upwards. In fact, with any unit contemplating the use of bituminous coal, the engineer would at least give consideration to the use of pulverized fuel as compared with any other method of firing and finally select equipment on the basis of the conditions surrounding the installation without questioning the use of pulverized fuel because of its being experimental. In the very large units, pulverized fuel is becoming the predominating method of firing bituminous coal. This has not been true of units under 500 b.hp., for such units are in smaller plants where methods that have been accepted for many years find more favor and where the owner is not so willing to experiment with or accept, without the stamp of approval of wide usage, equipment that has not backing of long experience.

The small boiler field is quite extensive and much greater than it would be desirable to cover in one paper, so it would be well to limit this discussion to what might better be termed the moderate sized small boilers. As 500 b.hp. verges on edge of units quite frequently installed in larger plants we will set 500 hp. as the upper limit. We could go down to the small house heating boiler as the lowest limit for there are examples of pulverized fuel being used in these units but that is a subject that may well be treated by itself. So let us set as the lower limit for purposes of this discussion boilers of 100 b.hp. as that is about as small a boiler as is generally found in power work.

In forecasting the future, it is desirable to be guided by past trends under similar conditions. Very few of the arts so well demonstrates the fact that we are living in the age of rapid development as the art of burning coal. It is only within the past 35 yr. that stokers have been used to any great extent. Less than 50 yr. have passed since the first commercially successful underfeed stoker was introduced and in that comparatively short space of time we have seen the progress that has been made in stoker firing of all sizes of boiler units.

Use of pulverized fuel firing for power boilers has only been generally accepted for larger units within the past 15 yr. but today it has reached a point where it is given prime consideration for bituminous coal-fired large boilers. That may, to some extent, be due to limitations imposed by sizes of very large boilers, where it has become increasingly difficult to obtain space for sufficiently large stoker areas.

In the small boiler field hand-firing is rapidly giving way to other means of firing. Hand-firing has very definite limitations and objections with which we are familiar and the tendency has been towards stoker-firing the small units. This has been a natural development and we can, in general, accept without question the desirability of stoker-firing as against hand-firing on the basis of increased economy, both in fuel and labor; increased capacity and improved conditions from the standpoint of the smoke abatement engineer. This last point is important and, in some localities, and under certain conditions, hand-firing of bituminous coal is forbidden.

We, therefore, must consider the future of pulverized fuel for small boilers in comparison with the future of stokers for the same units. On the basis of what has transpired in connection with large boiler units, we might expect that we will see more and more pulverized fuel used with smaller units. If this is true, then such use of pulverized fuel must be justified on a financial basis, both from the standpoint of capital investment and operating expense.

A stoker-fired installation to insure maximum operating efficiency under the load conditions imposed must be arranged with a setting of sufficient height and furnace volume to insure complete combustion. It should be arranged so that it can be attended with the minimum labor and, therefore, should be designed to operate at a rating so as not to produce fuel bed conditions that require excessive working by hand. The stoker must be of sufficient size to insure reasonable rates of combustion with due regard to the fuel to be used. There should be provided sufficient automatic control means to permit maintaining a fairly steady steam pressure under the load conditions existing. Coal supply should be of such nature that a steady supply is insured. Provision should be made for easy removal and disposal of ash. With pulverized fuel-firing under the same conditions, the same requirements fit almost exactly. For purposes of comparison, let us consider a 150-hp. horizontal return tubular boiler operating at a maximum rating of 150 per cent at 125 lb. pressure and 150 deg. feedwater temperature. This boiler was selected for comparison as it is one of the more popular sizes and types in the small

boiler field and is near the lower limit of the size boilers under discussion. The setting height may be taken about 9 ft. which is 1 ft. higher than the minimum suggested height and 2 ft. lower than the recommended height as given by the Stoker Manufacturers' Association. This same setting height is ample for a pulverized fuel installation for the removal of bridgewall provides for ample furnace volume and length of flame travel.

In both cases plain solid brick walls have been used, for the heat release with pulverized coal is only approximately 9000 B.t.u. per cu. ft., which is sufficiently low that excessive wall maintenance should not be encountered. A heat release of 12,000 B.t.u. per cu. ft. could be allowed for solid walls which would indicate that a lower setting could be used if necessary. Air-cooled walls or, in the case of the stoker, silican carbide brick on the clinker line could be used to reduce maintenance, but with the arrangement shown maintenance of the furnace should be about the same for either method of firing.

It has always been felt that the first cost of pulverized coal was so much greater than for a similar stoker-fired unit and this has been given as a reason for the slow progress in applying pulverized fuel equipment to small boilers. The above comparison shows a difference of only $302 in favor of the stoker which at 6 per cent is equal to $18.12 annually.

For operating costs certain assumptions must be made. We will consider that the units operate at an average of about 75 per cent rating over the entire year, including all shut-downs and banking periods or an annual production of about 1,000,000 b.hp.

Under these conditions we will assume an average overall efficiency of 70 per cent for the stoker and 75 per cent for the pulverizer. This appears to be the approximate difference that can be expected but will, of course, vary depending on conditions. If the time of banking is increased the stoker efficiency will be lowered while the pulverized fuel installation will not be so greatly affected as it can be operated intermittently as required to hold steam pressure.

Cost of Fuel

The stoker should be fired with a mixture of nut and slack coal to obtain the best results and we will assume a coal cost of $4.50 per ton. The pulverizer would require only slack coal which should be purchased for about 20 cents per ton less than nut and slack, or $4.30 per ton. We will further assume a heat value of coal 13,500 B.t.u. as fired. The comparison of fuel costs would then be a difference of $848.50 in favor of pulverized coal.

Average power consumption for the stoker will be about 1.5 kw. per hr. or 13,140 kw-hr. per year. The average power consumption for the pulverizer will be about 20 kw. per t. of coal pulverized or 33,100 kw-hr. per year. The annual cost of this power will vary according to the manner in which it is obtained and the difference in favor of the stoker will range from $23.45 for by-product power to $399.20 for power at 2 cts. per kw-hr. In a small plant we can assume that the labor required is at a minimum and there would, therefore, be no difference in labor costs for either system. It would be difficult to estimate the difference in maintenance. With the stoker-fired unit maintenance becomes a function of care in operation, the nature of the load and other factors difficult to evaluate. With a pulverizer, maintenance is a more stable item and is a function mainly of the amount of coal pulverized.

Experience indicates that in general maintenance can be expected to be about the same for either stoker or pulverizer. We can, therefore, compare the difference between the two systems on the basis of capital charges for the installation, fuel and power costs and we find the annual savings with pulverized fuel to range from $431.18 with 2 ct. power to $806.93 with by-product power.

It will be seen from these figures there is a saving in favor of pulverized coal-firing, mainly because of better efficiency and the use of a less expensive coal. The savings shown are, of course, subject to modifications with changes in coal costs and power costs. This example is given simply as an indication of what can be done under certain conditions and cannot be construed as representing the true comparison between all comparable installations of pulverized coal-fired units and stoker-fired units. Variations due to furnace arrangements, costs of pulverizers and stokers, size of equipment required for desired capacities, power costs and other factors must be taken into account, which might easily indicate greater economy with stoker-firing in some cases and with pulverized coal-firing in other cases. Each installation is a study in itself and must be treated as such.

There are some further intangible savings possible with pulverized coal-firing difficult to evaluate. For example, a pulverizer may be repaired without waiting for the furnace to cool as is necessary with a stoker. This may save considerable time of outage which may mean savings in production costs. A stoker is generally kept in operation until plant conditions make it convenient to take the boiler off the line. This may mean the stoker has to operate under adverse conditions at decreased efficiency.

The pulverizer will need replacement of worn parts at definite intervals, dependent entirely on the nature and amount of coal which passes through it. It is, therefore, possible to schedule definitely the periods of pulverizer shut-down.

Pulverized fuel equipment lends itself to considerable flexibility of arrangement. Connections may be made between pulverizers and boilers so that one pulverizer may serve more than one boiler. An extension of such an arrangement makes it possible to have a spare pulverizer ready to go into service in case of an emergency shut-down of another pulverizer, an arrangement not possible with a stoker. In some cases a pulverizer has been arranged on a movable platform permitting moving it from one boiler to another.

This reduces first cost and may be a desirable arrangement in some cases where extra boilers are available. In order to obtain the most economical power costs, pulverizers may be equipped with dual drives. Such an arrangement may be desirable where it is necessary to start up on outside electric power and then switch to the steam drive. The same arrangement may be used where it is desirable to start with the steam drive and change to the electric motor drive

after the plant's own generator has been put into operation.

A pulverized fuel furnace is ideal for oil or gas burning and in many cases combination burners are used which permit changing from one fuel to another. This provides for an emergency fuel and what is more important permits the owner to take advantage of varying fuel prices. Such an arrangement is common on the larger units and is equally applicable to small units. There has been considerable opposition to the use of pulverized fuel on the basis that a large percentage of the ash in the coal is discharged from the stack and spread over the neighborhood. In many cases this may be a just indictment of pulverized fuel but it seems to be the consensus of opinion of manufacturers of pulverizers that if the installation is properly engineered and if the fineness of grinding and the coal-air ratio properly maintained, there will be no more nuisance with pulverized coal than with stokers. It is probably easier to maintain proper combustion conditions with pulverized coal and so prevent smoke than with stokers. Fly ash from stokers is much coarser than the fly ash from a pulverizer unit and, therefore, the concentration is greater in the immediate vicinity of the plant. There have been a number of satisfactory installations of pulverizers in plants requiring cleanliness in their product, such as plants handling food products, paper industries, silk mills, etc.

It is evident from the foregoing that the manufacturers have made considerable progress with pulverized fuel in the small boiler field. Equipment is available. Experiences have, for the greater part, been favorable. Some mistakes have been made but it has been demonstrated that if good engineering is allowed to dictate the conditions of installation, the use of pulverized coal is successful when applied to small boilers. This by no means should be construed that pulverized coal can be used to replace stokers in all cases. There are many instances where conditions of operation and limitations in respect to the installation itself would indicate that stokers should be used.

As regards the future, pulverized fuel will undoubtedly increase in favor. Equipment for pulverized coal-firing will improve and since the pulverized coal art is comparatively young, progress will probably be more rapid than with stokers, which have reached the point of refinement where we can not expect as rapid advancement.

In the future pulverized coal-fired installations with small boilers, we can look for wider use of automatic combustion control. The necessity for automatic control is probably greater than with stokers for change to rate of steam generated should be accompanied by immediate change to coal and air rates and they must change in the correct ratio to each other to obtain proper combustion conditions. Proper guides to operation should be supplied if best results are to be expected. CO_2 meters, properly cared for, or steam-air flow meters are desirable. The day is past when the small plant should attempt to operate with a steam gage and water column if it is expected the operators are to obtain the most out of the equipment.

Burners are a very important part of a pulverized coal-fired installation. With the smaller boiler, there are wide varieties of furnace shapes and it does not appear reasonable to expect a single type of burner to give the best results with all types of furnaces. Pulverizers will, undoubtedly, develop along the lines of reduced power consumption, increased fineness and longer life of parts. In these respects they will follow the natural course of development as the result of studies being made with the larger units.

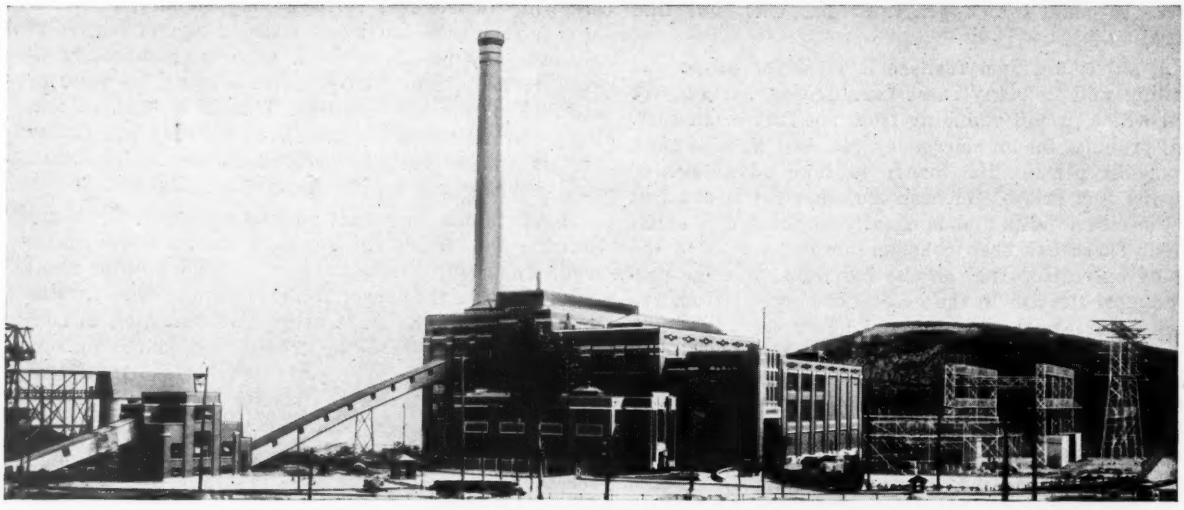
Feeders are important as it is necessary to insure uniform flow of coal with rapid response to change in load. The requirements are more stringent on the small units than on the larger for the amount of coal is so much smaller. The same amount of variation in coal feed, that would cause no trouble with large pulverizers, becomes a greater percentage of the total coal being fed and, therefore, results in a greater disturbance in the operation.

The possibilities of firing small boilers with pulverized fuel appear to be very favorable and with the experience obtained in an increasing number of installations, improvements in pulverizers and burners, owners or purchasers of small boilers should give serious consideration to the use of pulverized coal for replacing hand-fired installations and in selecting new equipment.

New Uses for Lithium

NEW INTEREST in lithium is developing rapidly. The therapeutic properties of lithium salts were utilized many generations ago. Even now "Lithiated" mineral waters consume a substantial quantity of lithium chloride, and the citrate and salicylate are employed as a remedy for rheumatism. Lithium hydroxide is employed in alkali storage batteries. Welding fluxes, principally those employed for welding aluminum, utilize either the chloride or fluoride. Lithium compounds have numerous minor industrial applications and among many suggested uses may be mentioned employment of lithium hydride as a carrier of hydrogen, provided it can be made cheaper, replacing compressed gas in steel cylinders. Interesting possibilities are in the rapidly growing list of alloying uses. For a number of years there has been a steady output of lithium hardened bearing metal alloys and due to the profound influence of rather minute amounts of this ultra-light metal in alloys, its sponsors envisage a wonderful future for it. However, the new use that appeals most to the imagination of the average man and consequently may mean most in the way of tonnage is for air-conditioning. Lithium salts are extraordinarily efficient for dehumidifying air and thus making the atmosphere more comfortable in hot weather. Sprays of concentrated lithium fluoride, for example, will extract a large proportion of the moisture content of the air and the moisture so extracted can then be easily removed and the solution regenerated simply by boiling it out again.

IN A DECISION handed down on June 24 by the New York State Supreme Court, the making of profit through the operation of a municipally owned electric plant and using the profits to reduce taxes was upheld in connection with a case involving Booneville.



Port Washington Station

America's Premier Station Put Into Preliminary Operation by The Milwaukee Railway & Light Co.

LOCATED on the west shore of Lake Michigan at Port Washington, Wis., 28 miles north of Milwaukee, the new Port Washington Station of The Milwaukee Railway & Light Co. was put into preliminary operation late in October. The new plant has adequate dock storage and handling facilities for receiving water-borne coal, an abundant condensing water supply, good rail connections and is in a favorable geographical position to handle the growing power load on the northern end of the system.

In addition to being the only central station built entirely during the depression period, it is an ultra-modern, simplified unit station of one boiler, one turbine and one set of auxiliaries, combining the utmost in heat economy with low unit cost. The initial capacity is 80,000 kw. with the ultimate capacity tentatively set at 400,000 kw. in five units although the flexibility of the station is such that no restrictions are placed on the size or arrangement of future additions.

Two Decades of Development Work

The design is the result of two decades of pioneering work with pulverized coal, high pressure, radiant superheaters and water conditioning, probably the most striking example of organized development by a single company to be found in the annals of the industry. Complete development along this line resulted in a boiler design with an availability equal to or greater than that of the turbine. It was this practical development work, principles proved in practice at Lakeside, that makes the single boiler-single turbine design of Port Washington practical.

In general, the boiler design follows closely that of the last unit at Lakeside. The boiler is of the 1390 lb., 850 deg. F. bent tube type with three forged drums, a total heating surface of 44,087 sq. ft. and a capacity of 690,000 lb. of steam per hr. The superheater is made up of 8700 sq. ft. of convection surface and 1464 sq. ft. of radiant surface, the latter made up of 2 in. chrome-molybdenum elements located in the side walls. The reheater consists of 1612 sq. ft. of 2 in. chrome-nickel elements in the rear wall.

Steam Temperature Control Automatic

In addition to the above, there is 7690 sq. ft. of water wall and water screen surface in the furnace which, measured above the water screen, has a volume of 58,000 cu. ft. Control of superheat and reheat temperatures at all loads is practically automatic due to proper selection of superheating elements. No economizer is used, the 121,000 sq. ft. plate type air heater being depended upon for complete heat recovery from the gases of combustion. The concrete stack is 300 ft. high above the base and measures 14 ft. 6 in. I. D. at the top.

Fans, all motor driven, consist of two 185,000 c.f.m. induced draft fans; two 112,500 c.f.m. forced draft fans and two 23,500 c.f.m. primary air fans. Coal will be pulverized by two 15-t. mills arranged for flue gas drying. A raw coal storage of 1100 t. has been provided so as to carry over the week-end without operating the coal conveyors. The pulverized coal storage of 290 t. is sufficient to permit shutting down the mills one shift and during peak load periods.

The generating unit consists of an 1800 r.p.m tandem compound turbine with 73 stages driving a 22,000 v., 3 ph., 60 cycle generator. The switchhouse

will be of the indoor vertical isolated phase type and the generator voltage will be stepped up in the substation for transmission over the 132-kv. system. The turbine is set over a 52,500 sq. ft., single pass condenser supplied with 110,000 g.p.m. of water by two pumps. Hotwell pumps are also in duplicate and pump through the steam jet air pumps, generator air cooler and two low pressure heaters to the boiler feed pump suction. Water in excess of feed pump needs is piped to the elevated float sealed surge tanks and is reintroduced to the boiler feed system, when required, through the condensate surge tank and main condenser which acts as a deaerator.

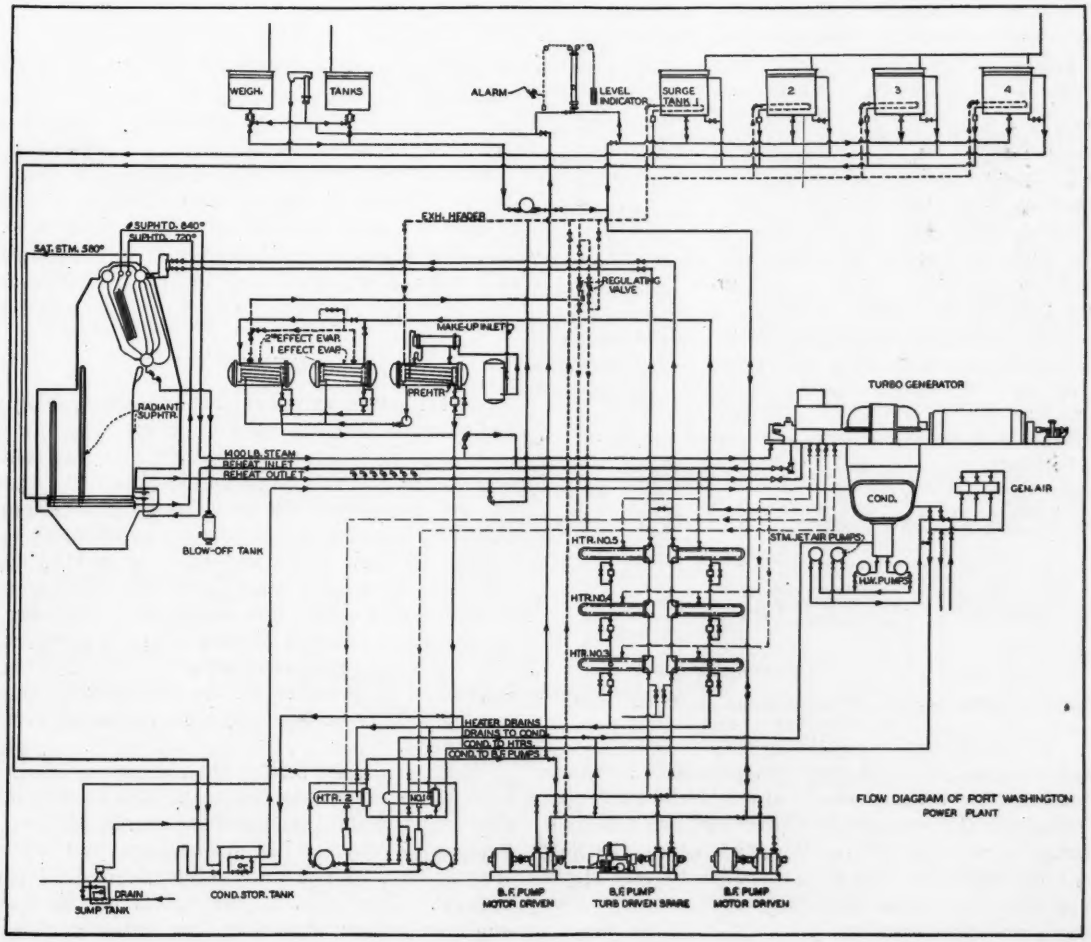
Heaters in Duplicate

Boiler feed pumps are located ahead of, and pump through, the three high pressure heaters. This eliminates possible pump trouble from handling water at high and variable temperatures, allows a more efficient and reliable pump design and in addition makes possible about 12 per cent saving in power due to the lower specific volume of water at 200 deg. F. as compared with 400 deg. F. The three high pressure heaters are each in duplicate as shown by a flow diagram, each of the two sets with a separate feed line and with a separate feed pump. A turbine driven spare pump is connected so it can serve either line. This arrangement improves feedpump regulation and if one set of heaters is out of service, enables the station to operate at normal feedwater temperature up to well over half load. Also costly bypass connections around each heater are thus eliminated.

Number 5 extraction heater takes its steam at reheat pressure while the other heaters are supplied by four lower extraction lines as indicated on the drawing. Steam for the double effect evaporator is taken from the same line as the No. 3 extraction heater while No. 2 extraction heater acts as the evaporator condenser. Exhaust from the two steam auxiliaries when in service will be used for preheating the evaporator water or in the surge tanks. Drains from the high pressure heaters, evaporators and preheater are cascaded to No. 2 heater and normally pumped back to the heater discharge line at this point, although they may be cascaded to the main condenser if desired. The design of the high pressure heaters is such that the condensate is cooled by the incoming water and the flash loss considerably reduced in this way.

Auxiliary Power

Auxiliary power is provided from 7500 kv-a., 3 winding transformers stepping down to 2300 and 480 v. for use with auxiliary motors of over and below 100 hp. respectively. Direct current for coal feeder drives, emergency lighting control, etc., is supplied by motor generator sets with a battery floating across the busses. The only steam driven auxiliaries in the plant are one boiler feed pump and one house service water pump.



FLOW DIAGRAM OF PORT WASHINGTON POWER PLANT

System Controls Air Conditioning

Comfort to the Human Occupant of a Room Depends as Much Upon the Relative Humidity of the Atmosphere as Upon the Temperature. The Modern Control System Regulates Both

By R. B. REAGAN

COMPRESSED air and electricity are the usual forms of energy used for operating the controls of an air conditioning system, the former having the preference for installations of over 25,000 c.f.m. capacity, up to certain limits, after which a combination of pneumatic and electric control is common. On small plants, electricity meets the requirements more economically and for large plants it transmits impulses more quickly to remote points, thus reducing the lag periods in correction of temperature.

While many arrangements have been devised for temperature control, no universally applicable system has been established because of the many variables encountered in different layouts. By coördinating control of the dew point, the room temperature and the admixture of fresh air, effective temperatures are readily maintained, this being accomplished by the use of suitable thermostats, hygrostats, pressure regulators, diaphram valves, damper motors and relays.

Forms of Thermostats

Three general forms are in use. The first is a bimetal type, utilizing the difference in expansion of two metals which are arranged in a curved strip so that a change in temperature alters the curvature and actuates various contacts for either compressed air or electricity so as to actuate valves or dampers as may be required. The second type has a small metal bellows filled with a volatile liquid or a gas, changes in temperature causing the bellows to expand or contract, thus actuating the valves or dampers of the system. The third type has a tubular casing of

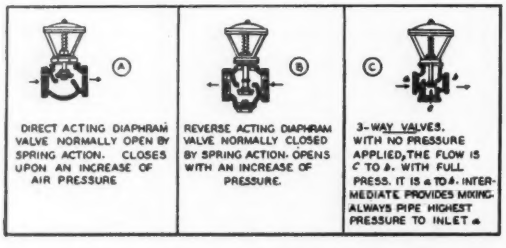

A
DIRECT ACTING DIAPHRAM VALVE NORMALLY OPEN BY SPRING ACTION. CLOSES UPON AN INCREASE OF AIR PRESSURE
B
REVERSE ACTING DIAPHRAM VALVE NORMALLY CLOSED BY SPRING ACTION. OPENS WITH AN INCREASE OF PRESSURE.
C
3-WAY VALVES. WITH NO PRESSURE APPLIED, THE FLOW IS C TO b. WITH FULL PRESS. IT IS a TO b. INTERMEDIATE PROVIDES MIXING. ALWAYS PIPE HIGHEST PRESSURE TO INLET a

Fig. 1. Diaphram valves. A, Direct acting. B, reverse acting C, three way

brass or aluminum which responds quickly to a change in temperature, with an inner rod relatively unaffected by temperature changes, on the end of which is mounted a valve so that as the tube moves, the flow of air is regulated. This type responds to very slight temperature variations and may be adjusted to give a graduated control effect.

In the differential type, one member is affected by the wet bulb temperature, the bulb of the element being kept wet by means of a wick or spray of water and a current of air kept moving over this bulb. The other member of the unit is a dry bulb, the two elements being so connected that the control is according to the wet bulb temperature depression below the dry bulb to pass on air pressure or electric current for the control of the water supply in the humidifier. Another type is actuated by hygroscopic action on a special element of silk thread, human hair or cross-grained maple wood, each of which has a tendency to alter its length or shape with a variation of the moisture in the air. This change is amplified by levers or gears and the motion used to control the opening of air ports, water or steam valves, air dampers as may be required to regulate the humidity.

Relay Systems

Pneumatic relays are divided into two groups, the graduated relay reproducing the graduated action of the thermostat so that by adjusting a tension spring which controls the diaphram of each relay, any number of relays may be operated from a single thermostatic circuit in any desired relation of sequence to each other. The positive relay is used to convert the gradual motion of a thermostat into a snap action of a valve, especially in fractional control of a heating unit to supply steam to sections as may be desired.

Diaphram Valves

Direct acting valves are held open by spring action and closed by pressure on a diaphram. The flow should be in such direction as to open the valve, so that pressure on the valve disc will be in opposition to pressure on the diaphram. Reverse action valves are held closed by a spring and opened by pressure on the diaphram, the flow being also such as to tend to force the valve open. For some purposes a three-way valve is used, which allows flow in one direction when there is no pressure on the diaphram and in another direction when full pressure is applied. Action of the valve is gradual as pressure on the diaphram is increased, so that mixing of flow may be maintained in any desired ratio.

Some engineers believe that, except in small installations, complete automatic control is inadvisable and that more constant temperatures can be attained, often with appreciable saving in operating cost, by control that is, say, 90 per cent automatic and 10 per cent manual. This adds to the duties of the operating engineer but requires more frequent contact with the

equipment in the conditioned area which results in better attendance and upkeep. Some installations maintain correct dry bulb temperature by action of the returned air on a thermostat located near the conditioning equipment. This has economical advantages but requires careful design as length of ducts and number of air changes will affect the action so that a surging of temperature may result giving alternate overheating and undercooling because of the time lag between temperature changes and damper adjustments.

In a common method of maintaining fixed dew point, hence a fixed amount of heat in the air, by mounting the dew-point thermostat in the casing of the conditioning unit, the intimate contact of the thermostat with the spray water maintains the even dew point at the expense of reheating air to offset excessive cooling during the summer season. The system has refinement but lacks flexibility, since, when there is balance in conditions outside and inside, there will be a cycle of cooling and heating that adds to operating expense. It is better to locate the thermostat in the path of unstratified air flow from the conditioning unit so that air rather than water is the controlling factor in maintaining the dew point.

For industrial work, where static electricity may be found, relative humidity should be kept above 40 per cent at all times. For comfort systems, it should not exceed 35 to 40 per cent during the heating season or moisture will condense on the windows; but going below 35 per cent to avoid frosting of windows should not be allowed, as a wet-bulb depression of more than 15 deg. is uneconomical from an operating standpoint.

In a system using direct expansion coils with moisture content controlled by shutting off part of the spray heads, it is better to shut off the top part of the spray rather than a vertical section, as this will maintain a constant load on the cooling coils at all times.

Various dampers for the control and mixing of the air should be of the louver type, light in weight, carefully balanced, of size to permit the passage of the necessary air at a velocity not to exceed 1000 ft. per min. and operated by gradual action motors. Fresh air dampers should be of capacity to pass the total air washer capacity to allow for intermediate season operation without recirculation of air. Where a definite amount of fresh air must be supplied to offset an amount drawn out for ventilation, as in restaurant kitchens, this can best be attained by the use of a manual damper of the required area, fresh air for balancing the rest of the system being under automatic control, to maintain the proper wet-bulb temperature. Sectional area of the bypass damper should be sufficient to handle all the recirculated air, should occasion require.

Freeze up in the fresh air heating unit during severe weather may be eliminated by using a direct acting diaphram valve to control steam flow to the heater, connected in series with a positive acting air motor for controlling the fresh air dampers, both these being operated simultaneously by pressure passed to them by a direct-acting thermostat placed in the fresh air duct. This pressure is further controlled by inserting a positive relay in the pressure line, which is normally closed and opens only when actuated by the dew-point thermostat.

Typical Control Hookup

No hookup can be of universal application but the one here shown contains the basic controls. It provides for handling the entire volume of air to be circulated. It has the spray banks controlled in two horizontal sections, the lower half for continuous flow, the upper for intermittent operation under control of air duct thermostat 5 so that with correct room temperature the upper part of the air washer becomes a bypass for returned air. Cycle of control is of the successive operation type so that the various valves, dampers and other equipment are adjusted to operate at certain definite pressures, the variations having their origin in one of the three thermostats 1, 4 and 5.

Summer dew point is controlled by the regulator 1, mounted and immersed in the air washer tank and set to pass air pressure when temperature increases above the range that will maintain the desired dew point. Since this is direct acting, increase of temperature

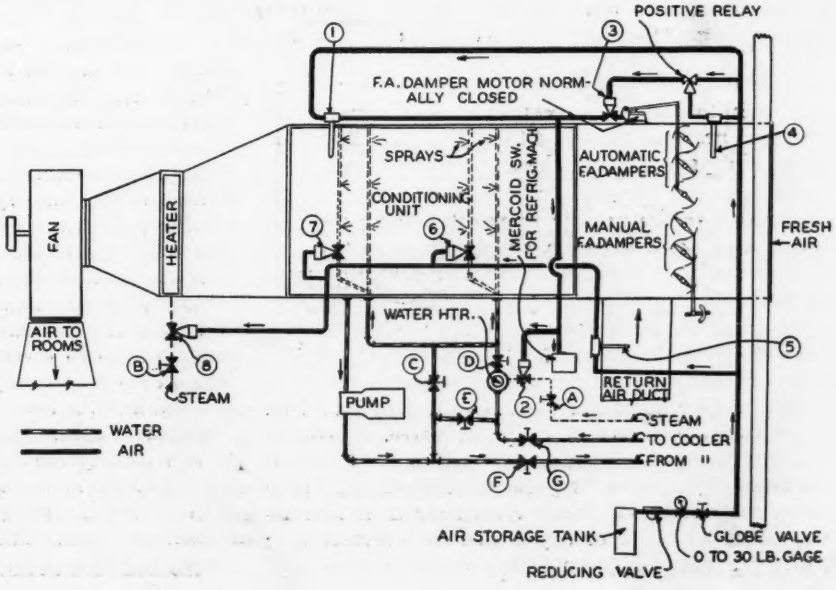


Fig. 2. Typical hookup for year around comfort control. For summer, valves C, F and G open; A, B, E and D open. For winter reverse the setting

will cause increase of pressure, the first impulse causing the direct-acting valve 2 to close. As the hand valve A is closed in summer, the action of valve 2 will have no effect.

As pressure continues to build up, the fresh air damper will operate at 4 to 6 lb. pressure, if the direct acting pilot valve 3 is in open position so as to allow pressure to pass to the damper motor. Valve 3 opens only when supplied pressure from the positive relay which is controlled by thermostat 4 mounted in the fresh air duct and set to act when fresh air is 55 deg. or less. If the wet-bulb temperature of the outside air is 55 deg. or more, the fresh air dampers will remain closed regardless of the action of thermostat 1 and pressure will continue to build up until at 8 lb. the electric control switch will be closed, starting up the refrigerating machine and this will continue to operate until the tank water is reduced to the setting of thermostat 1. This thermostatic regulator will then close, line pressure will be released and the electric circuit will be opened when the pressure is reduced to 7 lb. Also the fresh air dampers will close if they have been allowed to open by the pilot valve 3.

Winter dew point will necessitate adjustment of regulator 1 as a lower dew point is required, approximately 40 to 45 deg. F. Drop of tank water temperature below this new setting will cause a decrease of air pressure and valve 2 will open, allowing steam to pass to the closed heater. As the action is a reduction of pressure, there will be no tendency to open the fresh air dampers or close the refrigeration machine switch.

Rise of water temperature above the regulator setting results in retarding flow of steam to the heater, reduction of volume of water to the sprays by partial closing of valves 6 and 7; also, if further reduction of temperature is needed, fresh air dampers will open to such degree that the correct dew point will be attained.

In summer, room temperature is controlled by thermostat 5 in the return air duct, commonly set at 80 deg. Rise of temperature of the return air will result in a reduction of pressure and when this reaches 2 to 4 lb., direct-acting valve 6 will be opened, followed by valve 7, thus allowing full spray action to go into effect and reducing dry bulb temperature to the washer dew point. Conversely, reduction of room temperature and return air below 80 deg. will cause thermostat at 5 to pass more pressure, closing valves 6 and 7, then, if pressure reaches 8 to 10 lb., valve 8 will be opened and pass steam to the air heater.

Winter room temperature is maintained by the same action the return air thermostat being reset to 70 deg. and steam valves A and B closed so that the air heater is inoperative and the water heater becomes a cooler.

The instruments and their action are as follows: 1, direct acting thermostat for temperature regulation, passes air pressure with rise of dew point temperature; 2, direct acting diaphram valve, closes with 1 to 3 lb. air pressure; 3, direct acting pilot valve, controlled by 1 and 4; 4, direct acting thermostat for temperature regulation, passes air pressure at 55 deg. dry bulb temperature of fresh air; 5, return air duct thermostat, closes with rise of dry bulb room temperature; 6, direct acting diaphram valve, closes at 2 to 4 lb. pressure; 7, direct acting diaphram valve, closes at 3 to 5 lb. pressure; 8, reverse acting diaphram valve, opens at 6 to 10 lb. pressure; fresh air damper, opens at 4 to 6 lb. pressure; lettered valves are for manual control of steam and cooling water for regulating summer and winter operation.

Air Conditioning Simplified

J. F. Sweeney, Jr., Air Conditioning Division, Westinghouse Elec. & Mfg. Co.

AIR-CONDITIONING is a term that many have heard but few thoroughly understand. To define it in simple language we might say air-conditioning is a process which warms air when it is too cold, cools it when too hot, dampens it when too dry, dries it when too wet and cleanses it when laden with dirt or dust. Two different types of air-conditioning systems are now in use. More generally known, and used for large installations, is what engineers call the central system. All equipment for this type is located at a central point, from which conditioned air is distributed through ducts to various parts of the building. Another type, particularly suited for application in existing buildings and for the smaller businesses, the home and the private office, is known as the unit system. The name almost tells the story. The conditioning is performed by small units located in areas where the conditioned air is desired. These units are not much larger than the average hot water radiator.

Omitting confusing technicalities the system works as outlined in the following brief sentences. Air is warmed generally by passage over steam or water-heated surfaces. It is cooled by movement over refrigerated surfaces. To dampen it (humidification) the air is sent through passages where moisture is supplied by sprays. Drying is accomplished by lowering the temperature of the air and thus condensing out the moisture. To cleanse the air, either mechanical filters or water washing is used. Circulation is provided by motor driven blowers or fans.

Inside the cabinet of a modern unit air-conditioner is assembled equipment that provides proper air-conditioning the whole year 'round. Air from the room is pulled into the unit through openings at each end of the cabinet. Outside air, if desired, is brought through openings in the back of the unit by means of a duct. Across the top is the heating unit. Finned heating coils provide ample heat for the winter months and make other heating systems unnecessary. Below the heating unit is the cooling coil which is used during the summer months. With the refrigerant in these coils at about 40 deg. F., air passing through is cooled rapidly. In the summer these cooling coils also serve to reduce the humidity. When moisture-laden air is sent up through them moisture is condensed and falls into a drip pan while the cool dehumidified air is discharged into the room.

In the winter, often it is desirable to add moisture or to humidify the air. This is accomplished by two water sprays in the unit. Water is atomized in the path of the incoming air and is picked up and absorbed as vapor. The filter is a part of the outside casing and forms an attractive and protective top.

As One Engineer to Another—

The Chief learns about Steam Radiation and Radiation Specifications. By G. F. WETZEL

"WHAT is that bright red book, G.F.?" the Chief asked me as I sat down and laid it on his table. I held it up so he could see the back of the book, and he read aloud,—"The A.S.H.V.E. Guide 1935. That sounds like WPA, NRA, TVA, CCC, etc."

"Much different in meaning, Chief," I assured him. This alphabetical combination won't increase your taxes, and stands for American Society of Heating and Ventilating Engineers,—and their annual Guide is accepted as the most authoritative work on heating, ventilating and air conditioning that we have. It is a book you should be acquainted with as the ground it covers is pretty closely related to your field. I was just thinking that we haven't said anything about radiation and heat losses in buildings, and you ought to brush up on it, so this time we will do a little mental perambulating along that line. The principles involved are the same basic ones we have already discussed from several angles, so that they are not new to you,—just the application is somewhat different. You remember a good deal about heat and steam, and those are the principal factors involved."

"Radiation, meaning not radiated heat, but the physical heating equipment, is the most widely used type today, though some radical changes are being made in the small heating systems to meet the public demand for air conditioning. Existing buildings, hotels and apartments and factories will continue to use radiation which is already installed except here and there where extensive changes are being made. New buildings will use radiation in one form or another either for direct or indirect heating. Therefore we are not dealing with an obsolete subject by any means.

"In your plant at any time they may want to make changes in departments, or offices, or add new space that will require changes in the heating facilities. You will be the logical one to do the work unless it is a whole new building put up by an outside contractor,—so naturally you must know what you are doing.

"In any heating job there are two basic determinations to be made, first, how much heat is needed, and second, how that heat will be supplied. We will go into radiation first. This refers to cast direct installed radiation and not the heating units for indirect heating.

"We will assume that the heat quantity determination has been made, giving the number of B.t.u. per hour required. The next thing is to determine the amount of radiation required in equivalent square feet."

"Why do you say 'equivalent square feet', G.F.," the Chief asked.

"Because a square foot of radiation may or may not be a square foot of 144 sq. in. A so-called 'square foot of radiation' is really a measure of heat rather than area. Under standard conditions, an actual foot of radiation will emit 240 B.t.u. per hour if surrounded by unobstructed air. This is the actual measuring unit. When you stop to consider that radiators give out heat in two ways—by convection and radiation—you can see that radiator surface which 'looks' at other radiating surface at the same temperature cannot give radiant heat out to the room, but the two surfaces will radiate to each other, therefore the inner surfaces are not nearly as effective as the outmost surfaces, and it takes more square inches to emit 240 B.t.u. On the other hand, copper tubular or cellular radiation made something like an automobile radiator, has much greater heat emission rate due to both the thinner walls and the higher conductivity of copper as compared to cast iron, so this type is very compact, but usually is mounted in steel cabinets, to get the benefit of the chimney effect, and also to protect and conceal them."

Here the Chief had another question,—"I noticed that you said radiators emit 240 B.t.u. per hr. per sq. ft. under standard conditions. What are these standard conditions, and what difference do they make?"

"You know, Chief, that heat flow depends on the temperature difference between two points in the heat path, so that if there is a greater temperature difference there will naturally be more heat emitted. Therefore, since the radiation would vary with variations in temperature difference between room and the steam or water temperatures inside the radiator, we have to use definite temperature conditions. These standard conditions are 70 deg. room air and 215 deg. inside the radiator. Thus for a temperature difference of 145 deg. we will have a heat transmission rate of 240 B.t.u. per sq. ft. per hr."

"You mean, then, that if the temperature difference between room and inside of the radiator is less than 145 deg. there will be less than 240 B.t.u. transmitted through the radiator walls per square foot, and more if the difference is more?" was the Chief's next question.

"Right, Chief," I answered, "but not in exact proportion, so we use a table worked out in accordance with this formula:—

$$H_x = H_s \times \left(\frac{t_s - t_r}{215 - 70} \right)^{1.3}$$

where H_x is emission for conditions other than standard
H_s is emission for standard conditions
t_s is temperature inside of radiator
t_r is temperature of room

"This table gives the ratio of heat transmitted per square foot compared with 240 B.t.u. of $H_x \div H_s$. In the left hand column, you will remember, the 'In. Hg.' means inches of mercury vacuum. You will also notice that the second column is headed 'Steam or Water Temp.'. What would you gather from that?"

"I suppose," the Chief replied, "that it does not make any difference whether the temperature comes from hot water or steam. And I also assume that even if the water gets above 212 deg. it will not boil if the pressure is higher than that corresponding to the temperature."

"Correct on both points," I told him, glad to note that he was remembering his information about heat and steam.

"Now, the important thing is to apply this. Suppose you had a room that required 110,000 B.t.u. per hour, under standard conditions, how many feet of equivalent direct radiation (EDR) would be required?"

The Chief thought for a moment then answered, "110,000 divided by 240, which would be,—" he figured hurriedly on a slip of paper, "which would be 458.3."

Conversion Factors for Direct Cast-Iron Radiators.

Steam Press. In. Hg.	Steam or water temp.	TEMPERATURE OF ROOM				
		80	75	70	65	60
20.3	160	.462	.499	.538	.577	.617
17.8	170	.538	.577	.617	.657	.697
14.7	180	.617	.657	.6797	.740	.782
10.9	190	.697	.740	.782	.825	.868
6.5	200	.782	.825	.868	.911	.955
Lb.Ga.						
1	215	.911	.955	1.000	1.045	1.091
2	219	.947	.991	1.036	1.081	1.128
3	222	.973	1.018	1.063	1.109	1.155
4	225	1.000	1.045	1.091	1.137	1.183
5	227	1.018	1.063	1.109	1.155	1.202

"Okay. Now, if the conditions were 5 lb. steam pressure (ga.) and the room was 60 deg., what would the unit heat transmission be, and how much radiation would be needed? Refer to the table for your factors and be sure you use them correctly."

He looked down the "Steam Pressure" column to 5 lb., then read across to the 60 deg. column and picked out factor 1.202.

He multiplied,—240 $\times$ 1.202 = 288.48 B.t.u. per sq. ft. per hr.

He then divided,—110,000 $\div$ 288.48 = 381.3 sq. ft.

"I am certainly surprised at the difference in radiation required under the last conditions," he exclaimed.

"I am glad to see that you used the factor correctly. You could have divided your previous radiation by your factor 1.202 and gotten the same answer, but either way is all right," I told him. "Now try another one. Use the same heat loss 110,000 B.t.u., 75 deg. room temperature and 170 deg. water or vapor temperature."

He worked busily for a few minutes then showed me his paper:—

Factor 0.577

Heat emission = 240 $\times$ 0.577 = 138.5 B.t.u./sq. ft./hr.

Radiation = 110,000 $\div$ 138.5 = 794 sq. ft.

"I used this method," he explained, "because I wanted to see what the emission would be per square foot. It sure makes a difference what the conditions are."

"After you get the radiation, the next thing is to convert it into actual radiator specifications. Modern radiators are the so-called 'tube type', with the slender columns, from 3 to 6 deep and running from 20 in. to 38 in. high, also 7 tubes, 14 in., 17 in., and 20 in. high. Each size has a definite square foot rating for each section, running from 1¾ sq. ft., to 6 sq. ft. In selecting the radiator, pick out the depth, 3, 4, 5, or 6 tubes, and the height most consistent with the surroundings. Divide the total radiation by the rating of the section size selected. Then decide on the number of sections wanted per radiator, and the number of radiators, and place them to give the best distribution of heat, considering outside walls, windows, room conditions, etc.

"The previous style of radiators was the column type, the depth running from the single column to five columns, and the same heights as the later tube type, the low ones having six columns, with differently shaped columns, for under low windows, and window seats.

"If we selected 4 tube, 38-in. section, with 4¼ sq. ft. per section, we would need 458.3 $\div$ 4.25 or 108 sections. The sections usually run 2½ in. face to face, so that if we divided the 108 sections into 6 radiators of 18 sections each, they would be 45 in. long. Sometimes radiators of 40 sections or more are used.

"The latest trend in space heating is the use of suspended unit heaters, each with a propeller type fan. Due to high air velocity they have tremendous ratings. One or two unit heaters would handle easily the heating we have been figuring here. Their ratings are given in equivalent direct radiation, and also in B.t.u. per hour, based on tests by the manufacturers. These heaters, while efficient and effective, can only be used where the noise they make when running at full speed would not be objectionable.

"When it comes to blast or indirect heating, figuring the radiation is entirely different, because several new variables are introduced, the most important being air velocity. In determining the size of blast heating units, where ventilation and heating are combined it is necessary to refer to the manufacturer's data books, taking into account all the conditions.

"Oh, oh. Didn't that clock just strike five? That gives me just 10 min. to get my train, so we'll have to leave this heat problem right here. The next time I see you we are going to do some real calculating. Goodbye, Chief."

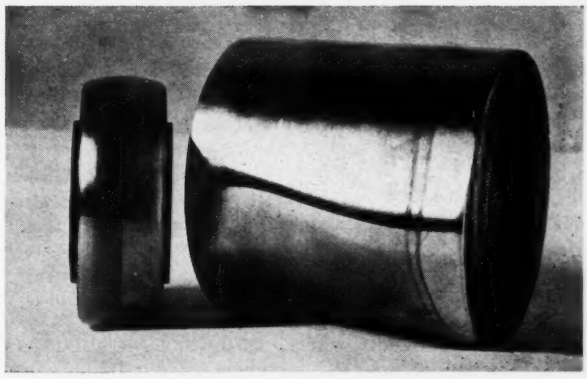
"So long, G. F., be sure to bring that red book along with you."

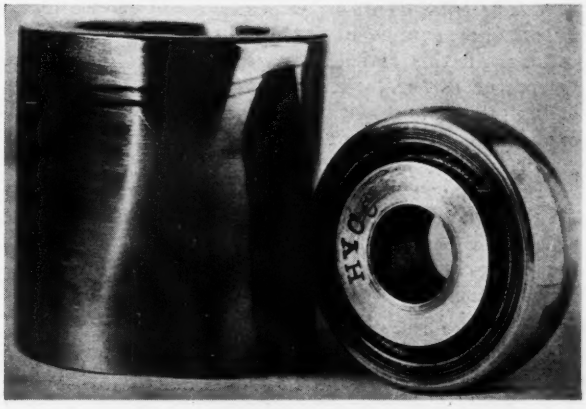
Definite upswing in business is also charted by the Federal Reserve Banks. Their records indicate that the low point of industrial production was reached in 1932 and the same year was noted a definite upturn in factory employment which has continued constant and growing during the years 1933, 1934 and 1935. In contrast to that the volume of construction contracts reached its lowest point in 1933 and the recovery since then has been noticeable but slight in volume. Construction therefore has a greater potentiality for recovery today than any other industry in the country.

Wear of Valve Cams on Vertical Engines

Records show that modern materials and proper lubrication have done much to reduce engine maintenance

By SCHUYLER C. PAGE





Cams and cam rollers after 650,000,000 operations

SOME YEARS AGO, the firm with which I was connected, decided to purchase a prime mover of about 600 kw. capacity. After making a thorough investigation as to the steam heating requirements and power demand, it was determined that an engine of high steam economy like the uniflow engine would best fit the condition. Space requirement was of prime importance and it was decided to remove a 200-kw. horizontal engine and install in its place, a vertical uniflow engine direct connected to an a.c. generator.

After all the available information was collected, a careful study was made especially of the various means of valve movement and governor control. This study naturally aroused the interest of the operators and periodical inspections were made from time to time after the unit was purchased and the installation completed.

This engine was put to a severe test over a period of approximately 30 mo. During the day, over much of the period, the engine operated on a comparatively steady load from 600 to 750 kw. and during the night (14 to 16 hr.) on a load varying from 100 to 600 kw. Night swings were often abrupt, dropping 500 kw. for 2 or 3 min. and again picking up as suddenly.

The point to be brought out by this explanation is that the governor and valve control mechanism was put to the hardest test that could be found in industrial power requirement. The wear and tear on the mechanism under the service described would be maximum, and many persons involved in the decision as to the type of equipment to buy questioned the ability of any material to give satisfactory life in the cams and cam rollers.

In the photographs, two cams and two cam rollers are shown. These cams have operated about 650,000,000 times as shown by the record of the engine hours in operation. Up to the time the photographs were taken, approximately 7,500,000 kw-hr. were generated. At this period, a thorough examination and dismantling and inspection of the governor and valve mechanism was decided upon and to the surprise of all making these examinations, practically no wear was shown on the surface of the cams, rollers and the roller pins. No wear could be detected by rubbing the fingers over the surface of the cam, and the rollers are in the same perfect condition.

It should however be mentioned that high grade equipment as described above, requires proper lubrication and this article would not be complete without a short description of the lubricating system.

This unit is of the closed crank case type. The crank shaft has three main bearings 8 by 11 in. and four crank pins 8 in. dia. by 6½ in. long. The unit is equipped with a pump and pressure oiling system that feeds oil to every moving part in the entire unit. The normal oil pressure is 20 lb. and the pump forces through this system 25 g.p.m. The entire supply of oil is forced through a disc type, all metal, self cleaning, pressure oil filter. The largest object that can pass through the filter must be less than 0.003 in. in any dimension. All the sludge and water extracted by the filter is passed under pressure to an exhaust steam oil heater so arranged that it maintains a discharge temperature from the heater of 180 deg. F.

Oil discharging through the heater, is passed through a centrifugal purifier where all of the water and oil is separated. Metal particles and foreign substances are passed off with the water, and the clarified oil returned to the oil system. After the oil passes the pressure filter, the main supply passes through a specially designed oil cooler and the oil leaves the cooler at approximately 130 deg. F. The oil that gives the highest degree of satisfaction is grade S.A.E. 40 with a flash test of about 510 deg. F. If the flash test is too low, too much oil is lost by evaporation and passing out as oil vapor from the crank case vents. When this unit was supplied with this grade of oil, it operated 24 consecutive months without adjustment. At the end of this time, the removal of a shim 0.003 in. thick was all the take up that could be effected in the connecting rod bearings.

Case Studies in Power Economics

Conducted by
ZUCE KOGAN,
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Candy Manufacturer Saves $2700 Annually by an Investment of $400 and Raising Back Pressure on Engine

IN SEVERAL of the previous articles, we have discussed conditions where, by taking advantage of changing conditions, an engineer could eliminate unnecessary equipment, or, where he could reduce losses by changing equipment not suitable for particular conditions. In this article, we wish to point out a case where the owner took advantage of the peculiarities of his plant, along with the peculiarities of his equipment, and secured considerable saving in fuel and power.

From the owner of a large candy manufacturing plant down to the foreman, all agreed that their plant was in the best possible shape, and, while they knew that improvements could be made with very large outlays of cash, they did not believe, and in fact they were certain, that no savings could be realized with minor expenditures. Somehow or other, we prevailed upon them, and the owners of this plant gave us the permission to survey the plant with the object of finding comparatively large saving possibilities with a minimum of expenditures, the latter not exceeding an amount that could not be returned out of savings in the course of six months.

Upon surveying the plant, we found that the boiler room equipment was in fine shape, and it was equipped with modern fuel saving devices, controls and meters. The equipment was kept in good repair and the picture of the steam generation presented no flaws. There was, however, a marked flaw in the utilization of the steam.

They had two 300-hp. Corliss engines. One was driving an ammonia compressor, the other a 200-kw. alternator. The ammonia compressor engine was going practically all year for about 20 hr. a day for five days a week in the summer time, and about 10 to 12 hr. in the winter. In the summer time it was used to help out an electrically driven ammonia compressor, and in the winter time it would supply the entire refrigeration load.

The load on this engine was practically uniform throughout the seasons and it was developing about 185 hp., consuming on the average 5700 lb. of steam per hour. In the winter months the exhaust of the engine, with rare exception, was sufficient to supply the entire heating load at a back pressure of about 4 lb. In the summer time, however, only a portion of the exhaust steam was utilized, namely, about 1200 lb. per hr. for chocolate warming up and melting, and about 600 lb. for boiler feedwater heating, the remaining 3900 lb. of steam per hour being wasted into the atmosphere.

The other 300-hp. Corliss engine driving the alternator was operated only during the months of November, December, and January, between the hours of 4:30 to 8:30 p.m. in order to take advantage of a low rate for the purchase of power from the local utility, as this rate called for a reduction of the power used during the aforementioned hours, thus allowing the customer of the utility a cheaper rate throughout the year. The engine, therefore, was practically idle the year round and no good use was made of a large investment.

Most of the process steam was at full boiler pressure. However, about 2400 lb. of steam an hour at 20 lb. pressure was used for heating water in a closed heater, and about 2000 lb. of steam per hour, also at 20 lb. pressure, was used for starch drying and in the drying rooms. That is, they required on an average of about 4400 lb. of steam per hour at 20 lb. pressure.

Analyzing these facts, we found a condition where low pressure steam was wasted during the summer months, and where a source of by-product steam was not fully developed and utilized, and where an intermediate pressure steam had to be derived from high pressure steam by means of a reducing valve.

On the basis of these facts, we recommended, that they operate the engine driving the ammonia compressor throughout the year at a back pressure of 25 lb., and that, in the winter time, the engine driving the alternator be operated continuously instead of a few short hours during four months, so that the exhaust of this engine could be used for heating purposes and thus obtain a portion of their power practically free.

Upon checking with the manufacturers of the engines, we found that by operating the Corliss engine at 25 lb. back pressure the maximum output of the engine would be 250 hp. In other words, an output sufficient to handle their refrigerator load both in the summer as a helping equipment, and in the winter when that engine assumed the entire refrigeration load. The water rate of the engine operating at a back pressure of 25 lb. was increased from 31 to slightly over 34 lb. per hp.

This arrangement, therefore, gave them a set-up whereby the exhaust steam of the Corliss engine driving the ammonia compressor in the summer time was saved, and it gave them a further possibility of saving on their purchase of power.

In order to take advantage of this change, a very small expenditure was required. All that was necessary was to interconnect the exhaust header of the engine into the 20 lb. pressure header with a series of valves, so that either the engine or the boiler may supply the starch and drying rooms.

This recommendation appealed to the owners of the candy manufacturing company and they made a small expenditure in the neighborhood of $400, and arranged

for determining the saving possible therefrom. At the end of the year, they found that they had reduced their power purchase cost by $1500, which consisted of $600 in demand charges and $900 in energy charges. By deducting a cost of $100 for the cost of steam lost upon the conversion of heat energy into mechanical energy, they have had a net saving for that period of $1400. This was as far as the alternator was concerned.

During the summer months they supplied the entire 4400 lb. of steam at 20 lb. pressure required for the water heating, starch drying, and drying rooms, by exhaust steam of the engine at 25 lb., thus reducing the waste of exhaust steam into the atmosphere. In spite of the fact that they supplied the entire 4400 lb. of steam per hour, the saving was only 3900 lb. of steam per hour, in view of the fact that this was the amount they wasted previous to the change, and the reason they could supply the entire 4400 lb. was because of the increased water rate of the engine operating at a higher back pressure. This 3900 lb. of steam per hour for 20 hr. a day, for five days a week, for 16 weeks, amounted to approximately 6,250,000 lb. of steam which at 21 cents per thousand pounds of steam, amounted to a saving of $1300 approximately.

Hence, the total saving for the year by being able to utilize the exhaust of the engine at a higher exhaust pressure, and generating a portion of the power during the heating season was $2700 with an expenditure of only $400.

The Reconditioning of Defective Metal Parts

METHODS OF REPAIRING cracks and other defects in various components of machines, and of reconditioning worn engine parts, have recently been introduced in Germany under the names of the Gussolit welding process and the Schliha metal-spraying process. As reported in a recent number of "Engineering" of London the Gussolit process is the result of exhaustive research on the part of Dr. Klopstock, who has developed a material described as a high-grade cast-iron alloy which is said to possess an extremely fine structure and possesses a Brinell hardness of 230. Few data of a technical nature regarding the process are available for publication, but it is reported that the part to be treated is heated to a temperature of from 850 deg. C. to 900 deg. C., coated with a special flux, and the Gussolit welding rod, which is supplied in the form of square bars, melted into the crack or defect. During the melting of the welding rod the flame employed is made to play in a direction parallel to the surface of the work in order to prevent excessive heating of the metal. Great stress, however, is laid on the fact that, owing to the moderately-high temperatures employed, there is no distortion of the piece as a whole. It is reported that cracked motor-car cylinder castings, turbine casings, and other engine parts have been successfully repaired in this way, the Gussolit alloy penetrating deeply into the cavities and making a strong and sound joint. Defects in machine-tool components have also been made good by the use of the new process. In one such instance after the final grinding operation, three blow-holes were revealed on the working face of the arm of a radial drilling machine. These were filled with Gussolit, and after regrinding, the arm, it appears, presented a uniform and smooth surface free from blemishes. The coating of porous high-pressure steam and hydraulic-press cylinders with a thin layer of Gussolit, it is claimed, has enabled them to withstand pressures of 130 atmospheres, whereas previously leakages had occurred, owing to porosity, at pressures of 25 atmospheres. Again, parts previously rejected owing to faults of workmanship, such as holes having been drilled too large, are said to have been successfully reclaimed by the application of thin layers of Gussolit.

The Schliha metal-spraying process is used mainly for the building up and reconditioning of worn engine parts, such as internal-combustion engine cylinders, shafts and bearings. A special spray pistol is employed and the metal to be sprayed which may be steel, bronze, copper, or aluminum, is fed automatically, in the form of wire, to the nozzle where it is melted by an oxy-acetylene or oxy-hydrogen flame and projected as a fine spray by means of compressed air at a pressure of about 37 lb., the compressed air, incidentally, also having the effect of cooling the nozzle. While the data available are somewhat meager, a good deal of work appears to have been carried out on the spraying of steel, and it is claimed that a layer of steel of any desired thickness may be sprayed on to a worn surface and that the coating is very firmly adherent and can be subsequently ground to size. Steel sprayed on to the surface of worn engine cylinders is stated to have a Brinell hardness of 300. As already indicated, the thickness of the sprayed layer may be controlled at will, but it is pointed out that this should not normally be less than 1 mm. The procedure adopted is that shafts and similar components are rotated in a lathe and the worn parts built up by allowing the spraying pistol to rest on the headstock of the lathe. For the internal spraying of hollow objects, nozzles bent at an angle are used, the piece being rotated in a lathe as before. For the spraying of worn internal-combustion engine cylinders, however, an automatic machine has been designed, in which the spraying nozzle, and not the work, rotates. The rotating nozzle is driven by a small electric motor, which also governs its vertical motion, thus it is claimed that the entire surface of the cylinder bore is capable of being given an evenly sprayed coating. Excess steel particles are removed by suction, the cylinder casting standing over a hole in the base plate of the machine; the suction, it is stated, also has the effect of cooling the cylinder. It is claimed that by the use of the machine a cylinder 75 mm. (2.95 in.) in diameter and 147 mm. (5.79 in.) long can be given a sprayed coating 1 mm. thick in 25 min. For dealing with multi-cylinder engines, machines equipped with up to 12 automatic rotating spraying pistols, we understand, are being employed. Thus, it is stated that an engine having 12 cylinders of the dimensions given above can be sprayed to a depth of 1 mm. in 25 min. Another interesting application of the new process, we understand, is that of the spraying of piston-ring slots with steel as a precaution against premature wear, and it is stated that a firm of aero-engine manufacturers is adopting this procedure.

Readers' Conference

Disconnection Trouble with Portable Tools

THE EXTREME convenience of portable tools of all kinds has widened their use continually of late years. About the only "fly in the ointment" with reference to the use of such tools is the fact that they must often be plugged into sockets that are suspended overhead, and the weight of the cord tends to disconnect the tool. In some cases, the cord is given a jerk by the foot of some passing workman that causes disconnection to take place. This can be quite exasperating.

One method used to make certain that the plugged connection will remain in place until the job has been finished, is to take a stout rubber band, and wrap it quite tightly by continuous looping around the wire just above the plug-in socket. Then, when the tool has been plugged into place, one or two or more loops of the band is pulled down and snapped into place under and around the pronged half of the plug. The rubber band can be left permanently in place on the upper half of the plug or above the light socket until it has deteriorated enough from age to make it useless, when a new rubber band may be substituted.

This problem has been solved, however, by a manufacturer who has designed a type of plug which locks into place securely by simply twisting it after plugging in. Plants using this type of plug enjoy the utmost in convenience from their portable tools, and it must be admitted the scheme is superior to the rubber band idea.

Peoria, Ill. JOHN E. HYLER.

Flywheel Repairs

RECENTLY a flywheel in one of our large engines worked loose and sheared the key. Due to limited time and the construction of the building it was necessary to replace this key without removing the shaft or wheel from the pit.

To do this the crank was first placed at about 90 deg. so as to set the key on top and the bolts upright. The four bolts were then slacked off and, with a bar, chisel and maul, wedges driven between the hub sections at each corner. The wheel was then jacked tight against the shaft and the key driven out. As the key came out it was necessary to saw off about 4 in. each time until it cleared the end of the key way. The new key was made slightly larger than the old one and cut in two parts as, due to the close clearance, it was not possible to get it in in one piece. Even then it was necessary to move the wheel all the way over against the pit walls.

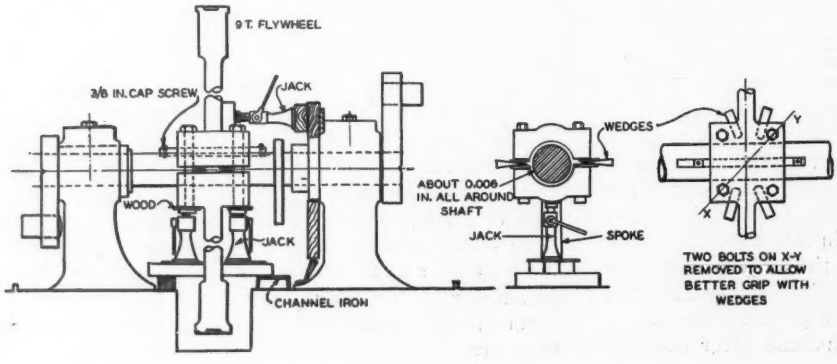
To move this wheel the journal cap bolts were first loosened and the shaft centered in the hub by means of the jack shown in the illustration. The third jack shown in horizontal position was used to force the wheel over. The additional squares and ⅜ in. cap screws at the end of the keys were suggested by another person and were added to hold the two pieces of the key in position so that if the wheel shifted they would not be carried along with it. Personally I feel that if the wheel moves at all the cap screws would be sheared off without difficulty.

It took 3 or 4 hr. to get the jacks rigged up and about 2 min. to shift the wheel over. Although it tided over the emergency, I would not advise this method except under unusual conditions similar to those we encountered or where shop work could not be done.

W. C.

Furnace Designs that Failed

SOME applications of pulverized fuel that did not work out as desired are illustrated in Figs. 1 and 2 which show the desirability of professional engineering advice. Figure 1 shows the application of a pulverizer to a water tube boiler. This boiler was originally fired by three underfeed stokers and operated at 200 to 250 per cent of rating. No trouble was encountered in maintaining the steam pressure required beyond the grief usually met with in this type of stoker, which was hand cleaned. The engineer in charge recommended and superintended the installation, expecting to get greater efficiency and capacity with less labor. The furnace, of dutch oven type, was lengthened and the front and side walls built with a 4-in. air space between the fire brick and clay brick walls. A bridgewall was made by pouring a solid concrete block capped with plastic fire brick.



Details of how a 9 t. flywheel was shifted to fit a new key in an emergency. The governor pulley and eccentric were loosened and shifted over to the bearing pedestal so as to give additional clearance and the key was then put in in two pieces

Everything started as planned but they ran only about 12 hr. until difficulty was encountered in keeping up steam pressure, which grew worse until they had to shut down. It was found that the fine concrete bridgewall had gone to pieces and the heat developed in the furnace was passing up under the lower drum and up the last pass bypassing the first and second passes.

This was repaired by rebuilding the bridgewall of plastic fire brick and slightly changing the angle of the burner so that the flame did not impinge against

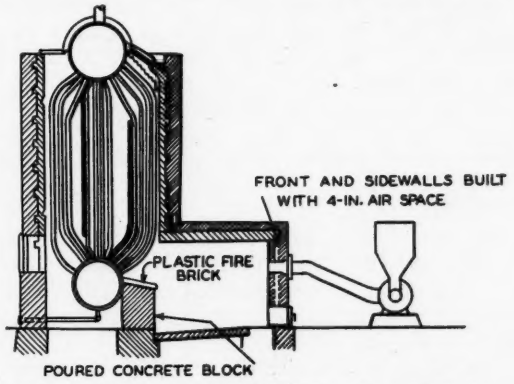


Fig. 1. Unsuccessful Pulverized Coal Furnace Design

the bridgewall so directly but went more into the throat of the first pass between top of bridgewall and arch formed by furnace roof.

That arrangement held for a while until one day the dutch oven was wrecked. What happened, as near as could be found out, was that coal dust got in between the walls and exploded, blowing the side and front walls to pieces, allowing the roof or arch to fall down between them.

After that the whole layout was rebuilt under the direction of a man connected with the manufacturer of the pulverizer. They built up the furnace in front of the boiler setting to a height sufficient for what was required and placed the burner in the top so that the flame traveled down and under what they called a curtain wall and then up into the front pass. This stopped the firing troubles.

Figure 2 shows the layout of a pulverizer as applied to a scotch wet back boiler which, before this application, had been fired by a single retort underfeed stoker set directly in the corrugated flue as was usual with this type of boiler. The reasons given for the change were: too high repair bills on the stoker, too limited capacity, a desire to burn a cheaper grade of coal, and last, that it took too much steam to operate the stoker. All exhaust steam was used for heating. A pulverizer of the peg mill variety was purchased, also a 35-hp. motor to run it. The stoker was torn out, excavation made for the furnace which was built as shown, and the corrugated flue, formerly used as a furnace, was lined its full length with fire brick. Everything being installed and ready, a start was made.

After pressure was raised in the boiler and the boiler cut in on the line they began to "give her the gun." First round—the furnace wall cracked and heaved itself nearly to pieces. It was repaired by being tied together with rods and buck stays in almost every conceivable direction. Another start was made and this time the furnace stayed together but the tubes burned off in the combustion chamber. These were replaced and the fire brick lining removed from the corrugated flue.

They had discovered that for some strange reason flue gas temperature was abnormally high.

Now things began really to hum. There were three boilers of this type installed in this plant and at full load all were needed to carry the load, when stoker fired. One of the stoker fired boilers was cut out of service and then the other, and the whole steam load

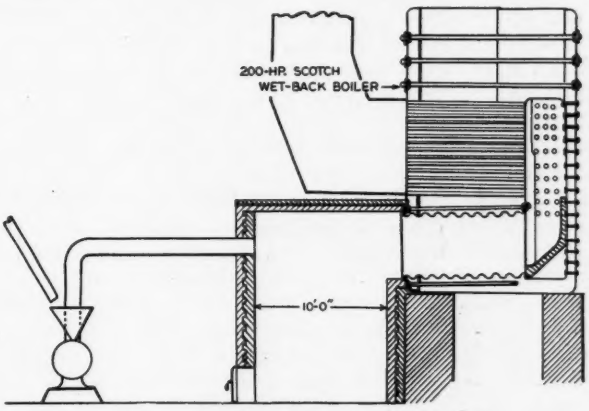


Fig. 2. This Design Proved Uneconomical

was carried on the pulverized coal fired boiler, using a grade of coal called "dock sweepings."

About this time another engineer, who was long on investigating the "what and why" of things came along and asked permission to investigate the layout. What he found out was plenty. Unconsumed combustible escaping up the chimney in the form of fine coke amounted to a considerable loss. High flue gas temperature, a poor showing of CO_2 in the flue gas, heat radiation loss through the dutch oven walls and the power consumed by the motor running the pulverizer, all added together, not to say anything about the repairs to furnace, boiler and pulverizer, brought the total cost of steam produced to a higher price than when three boilers were operated and stoker fired.

Another thing, they found out that with that particular type of mill, when the pegs wore, the size of the coal delivered to the furnace increased until, if allowed to continue without renewing, the whole bottom of the furnace would be covered with coal too large to burn in suspension. That called for frequent peg renewal. The last report on this installation was that the pulverizer had gone out and the stoker had been replaced in this boiler.

Superior, Wis. FRED S. RUTLEDGE.

Explosions in Engine Crankcases

EXPLOSIONS have occurred and are always liable to occur in engine crankcases owing to the ignition of the combustible gases given off from the lubricating oil. If the operation of the engine is normal the lubricating oil would not be heated enough to give off sufficient gases to cause an explosion, but if the engine overheated, more gases would be given off, the production of gases being assisted in all cases by the oil being splashed about.

Under these conditions lubricating oils do give off combustible gases but very seldom in sufficient quantities to cause a severe pressure rise and spontaneous combustion, but if any part in contact with the lubricating oil becomes severely overheated, the heat might be sufficient to ignite the oil. When opening up an enclosed crankcase after an engine has been running, an open light should never be brought near until the engine has cooled to normal running temperature.

The risk of explosion is greatest with internal combustion engines, but I know of one instance where there was an explosion in a steam engine crankcase, this being due to an overheated slipper block. With internal combustion engines the risk is greater, this is due partly to the higher temperatures and also to the fact that the engine piston rings may be leaky, permitting gases to blow by with the result that in time the lubricating oil used becomes contaminated with fuel oil.

I have experienced one explosion in an internal combustion engine crankcase, the engine in question was a two stroke, employing crankcase compression of the air. Force feed lubrication by pump being used. With this class of engine it is necessary to keep the crankcase drained. The engine was just being started up after an overhaul, the fitters in putting back the engine piston had used lubricating oil to decrease the friction between the piston and the liner. This oil had collected in the crankcase which had not afterwards been drained. The explosion occurred when the engine was being restarted after a short run, it was warm but there was not sufficient heat to cause ignition. The risks of crankcase explosions, however, are negligible provided no part of the engine is allowed to heat unduly for any length of time and the piston rings are kept so that no blow-by of gases can occur. It is also advisable to avoid using kerosene for flushing out the internal parts of an engine, or if it is used, to be sure that it is afterwards completely dried up.

Kent, England — W. E. Warner.

Where Silence Is Essential

A large liner was proceeding slowly up the Hudson River to her berth. In the engine room eight or nine white clad engineers were at the control wheels and telegraphs alert to obey orders from the bridge.

One of the juniors was whistling to himself at his work when he felt a touch on his shoulder and, turning, faced the senior second.

"Laddie," said he, "never make any unnecessary noise in the engine room. A good engineer uses his nose and his ears even more than his eyes and any sound other than the normal ones send him looking for trouble. Keep quiet down below unless in emergency when the sound of your voice will galvanize your assistants into instant action."

These words were taken to heart by the young engineer and the passing years have shown him their truth.

He wished one of his colleagues had learned this lesson several years later when he was alone on watch in the engine room of a very old, very worn but still valiant freighter. On this vessel he was the "clarty second" and, one afternoon, he heard a regular and persistent squeak. It sounded for all the world like a brass bearing crying for a drink and corresponded to the beat of the reciprocating engines.

He felt around his top and bottom ends far quicker than a Liverpool fireman gets ashore but they were all at their normal temperature and showed that white foam at the ends that is a sure sign of "all's well." He made a slower and more detailed inspection of the main bearings, eccentric and link bearings. Still no sign and the squeak still there. It seemed impossible to place where it came from. The auxiliaries were alright and, finally, he climbed the ladders to the cylinder tops. Here the noise seemed, if anything, more pronounced.

In a little spacing on this level was a small bench and vice. In the vice was a long piece of 5/8-in. brass rod and, before it stood the fourth, busily engaged in putting a long thread on it with the stocks and dies. This was the noise.

The second tried hard to think of a text to meet the occasion but portions of the Black Mass were all he could think of so he proceeded sadly below.

During the war he was master mechanic at a large factory employing many hundreds of girls. Like most females they communicated with one another by shrieks. Most of the day the air was thick with high, falsetto voices and catcalls over the hum of the machinery.

One day a girl got her finger caught between slowly moving rollers. She shrieked plenty but, accustomed as were we all to the incessant noise, we took no notice. The rollers drew in her hand, wrist and forearm before it was seen and the machine stopped.

It was this engineer's job to apply a tourniquet and raise the rollers to free the bleeding, pulpy mess that was all that was left of what was a girl's arm a moment before.

When she eventually left the hospital she had a stump only and she could thank the needless, unnecessary noise she and her mates made for it.

Passaic, N. J. — Mark Bell.

Consult the Operating Engineer Too

I have listened to the complaints of so many operating engineers that I decided to write the following which I hope will make fellow operating engineers complaint-conscious and result in a rectification of this major fault.

At a gathering of operating engineers which I attended recently, several were complaining that they had been either hired fresh or transferred to a new plant. This plant had only recently been completed and that up until the time they were asked to take over the operating responsibilities the experience of a competent operating engineer had not been consulted. The architect and consulting engineer approved the design, layout and specifications for the equipment to be installed, but as to the operation, well, that was left for the operating engineer to worry about.

My friends complained that they had to wait until they assumed charge before they could offer their suggestions, which were then merely idle words because no changes were approved unless they were found to

be of a serious nature. Thus the operating engineer had to live with the equipment whether or not it was up to his operating standard.

Usually the points in question were minor ones, such as locating a small battery charging motor-generator set in the basement instead of in the operating room where it belonged and where there was ample space available for its installation. The operating engineer complained that a man always had to be sent down two flights of stairs to inspect the remotely-controlled unit before it was put in service whereas if it had been located in the switchboard room the inspection would have been a matter of a minute or two. Other points complained about were, storage facilities for lubricating and insulating oils; location of fuses, resistance tubes and lamps; the need of stop valves with a section of one or two feet of pipe on either side of the water meter so these pipes could be quickly removed for inspection for evidences of galvanic corrosion (lead pipe and brass meter) and reinstalled or replaced; accessibility of the ground connections to the water pipes so the joints could be readily inspected for oxidation and corrosion, etc.

I feel the operating engineers are justified in their complaints and should be invited in at conferences with the architect and consulting engineers when a power plant is being contemplated. True coöperation in the final analysis results in progress in the art of power plant operation.

Woodcliff, N. J. KERMIT B. HOFFMAN.

Emergency Methods

WHEN A number of tubes failed in a sawmill boiler, new ones were not immediately available. To prevent a prolonged shut-down while waiting for the arrival of new tubes from a distant supply house, the defective ends were burned off and suitable pieces of second-hand (or old) tubes of the same diameter but shorter in length were welded onto the tubes which failed. These improvised tubes gave satisfaction, enabling the mill to keep up production until there came a slack period, when the new tubes were installed and other needed repairs made.

At a sawmill which was very remotely located, the millwright found he had no man-hole gaskets. Not wishing to wait several days for the arrival of gaskets, he fashioned some from a heavy truck inner tube. He found that by burning strips of rubber and allowing it to drip on the man-head a sticky, gummy surface resulted, to which the gasket clung as if glued in position. Such a gasket is still in use at the lower man-hole, where water prevents heat cracking; but it is doubtful if such a gasket would stand under the heat and pressure to which it would be subjected at the upper man-hole. It pays to use only the best of packing, never using inferior material where steam pressures are high.

Only those who have had experience or training have sound ideas about how much long steam lines expand when steam is turned on or how much they contract upon cooling. The answer is the same under both conditions. My first experience was with an inch line leading to a steam jet 600 ft. distant. I shall mention that the steam line was reduced to ½ in. where it entered the jet vertically from an elbow in the line. Probably you have already guessed what happened when steam was turned on the line in an effort to make the jet operate. Expansion in the steam line caused the latter to break squarely off where it entered the jet (vertically). Evidence of expansion to the extent of 6 in. was present at the jet end of the line and I believe there was almost the same amount at the opposite end. I believe 1½ in. of expansion to each 100 ft. of 1 in. pipe is a conservative estimate. Much depends, however, upon the composition of the pipe, the general shape of the line and the temperature.

Only the best expansion joints obtainable should be used in long steam lines for permanency.

McCool, Miss. BUNYAN KENNEDY.

Distillate in Gasoline Engines

Q. Have you accurate information available as to the best method of arranging the ordinary gasoline, or automobile type engine to burn distillate or lower grade fuel? This is done by a number of companies at the present time but I do not have any details as to the best methods for reliable and satisfactory operation.

A. On the subject of burning distillate in automobile engines, I would point out that distillate is a general name and covers a wide range of fuel characteristics and fuels from many different oil fields. With the exception of distillate from a few California crude oils, the octane rating is much lower than that of gasoline and I believe all so-called distillates are of much higher boiling point and lower volatility than gasoline.

In view of the above points, it is necessary that the compression of an automobile engine be lowered if it is to operate on distillate. It may be that it will be practical to retard the spark instead of lowering the compression providing the valves will stand it without burning. On account of the high boiling point of the distillate, it is desirable to use more heat, preferably on the intake manifold, but in some cases it is sufficient to adjust the cooling system so that the engine runs quite hot, approximately 180 deg. F. Even then the crankcase oil must be watched for excessive dilution. An automobile engine running on distillate is much more likely to give satisfaction if load and speed are fairly constant so that the throttle is not frequently opened and closed.

In some distillates and in some climates, it will be necessary to start the engine on gasoline. The writer has frequently burned distillate in an automobile while living in California and found one good method of starting when the engine was cold was to have a pint of gasoline fastened to the engine bulk head and inject a spray of this gasoline into the upper part of the intake manifold with a pump type primer such as the Lunkenheimer Primer used on aircraft. By pumping this primer at the same time that the starter was engaged, the engine started very well without further need of gasoline.

It is possible that carburetor adjustment will be necessary in some cases but this is often unnecessary. Obviously as the compression is lowered or the spark retarded, a lower power output will result than when running the engine on gasoline.

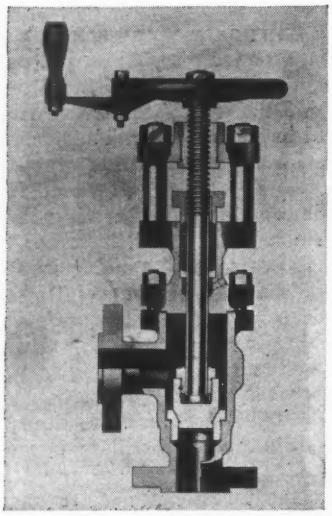
Answered by Geo. E. A. Hallett, Head Power Plant Section, Research Division of General Motors Corp., Detroit, Mich.

New Equipment

Hard-Seat Blow-Off Valve

SUPPLEMENTING its line of seatless blow-off valves, the Yarnall-Waring Co., Philadelphia, Pa., announces the forged steel hard-seat blow-off valve as illustrated. This valve, made for two pressure ranges, 600 and 1500 lb., is of the seat-and-disc type, with the inlet under the seat.

The body is a flanged steel forging of angle pattern with a side outlet and with a bottom flanged inlet nozzle screwed in and welded. A stainless steel seat ring, heat treated and ground, is screwed into the nozzle on the lower end of the

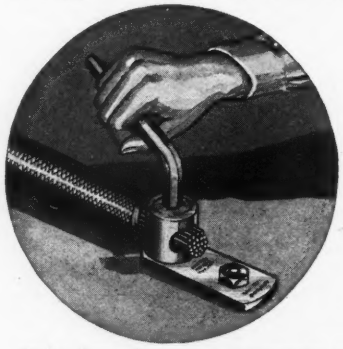


body. A pillar or marine type yoke with a threaded bushing provides a simple, sturdy guide for the steel stem. The stainless steel disc is attached to the stem by a disc nut pinned in place. The disc bevel is faced with stellite, then ground, to provide smooth hard-wearing surface at this important point on the lip on the lower end of the disc, checks wiredrawing action of the blow-down and protects the bearing faces of seat and disc. The stem has a shank extending above the packing so the threaded section is not exposed to high temperatures.

When the valve is wide open, the top of the disc nut seats against the bottom of the bonnet permitting repacking under pressure. A condensing chamber in the bonnet is provided with a small test outlet to insure relief of pressure before repacking the stuffing box. The steel packing gland is fitted with a bronze liner to prevent cutting of the stem. An Alemite fitting on the cross yoke provides lubrication of the stem and the operating handle on the hand wheel gives added power for the closing valve against high pressures.

Solderless Cable Terminal Lugs

A LINE OF SOLDERLESS cable terminal lugs, called Wire Grips, has been recently placed on the market, by Bull Dog Electric Products Co., Detroit, Mich., for which the following advantages are claimed.



Only five sizes are necessary to cover the entire range of wires and cables from No. 14 to 1,000,000 cm., a size for every requirement.

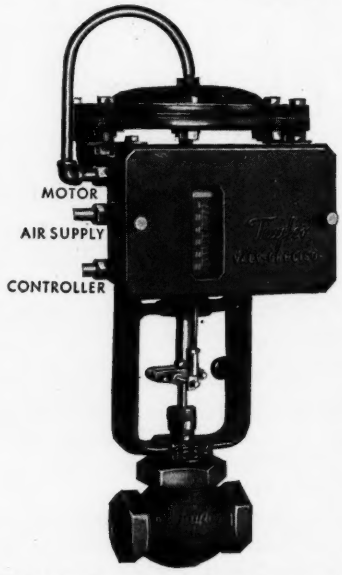
As these wire grips are neither castings nor forgings, but made by a special process, it is possible to use pure electrolytic copper for the composing metal, thus assuring highest conductivity. This process of manufacture also preserves the structure of the composing metal, thus increasing the mechanical strength, so that wire grips can "take" all the clamping necessary for good contact.

Clear wire holes give positive visual evidence of the degree of contact.

Industrial Control

FOR INDUSTRIAL LOAD CONDITIONS where load changes are not a problem but the valve stem friction and diaphragm motor hysteresis must be overcome to obtain precision control, Taylor Instrument Cos., Rochester, N. Y., developed the "Valv-Precisor." This device is recommended by the manufacturer on all processes which have time lags or heat capacities demanding low or medium controller sensitivity and with infrequent or negligible load changes. It is unnecessary on processes with short time lag which permit a high controller sensitivity and should not be used on processes involving large time lags or load changes. For these applications the manufacturer recommends the Taylor Dubl-Response system.

The "Valv-Precisor" can be used with any air operated controller but must be so located on the



diaphragm valve that a direct rigid connection may be maintained with the valve stem. The only necessary adjustment is to adapt the mechanism to the full travel of the valve stem. An indicator shows the actual percentage of valve opening through a small glass window.

FOSTORIA TITESEAL is the trade name of a compound recently made available to industry by the Fostoria Pressed Steel Corp., Fostoria, O., after severe and exacting use in aviation service. It is used permanently to seal leakage of gas, vapor, oil, gasoline, steam, water, grease, alcohol, glycerine and special anti-freeze solutions and is obtainable in three densities to suit the various types of service.

Laboratory Crusher

WHEN INSTALLED with a motor and ready for operation, a new laboratory crusher and pulverizer being offered by the American Pulverizer Co. of St. Louis, Mo., occupies no more space than an ordinary office desk. In addition to being useful in connection with laboratory analysis of coal samples, the crusher is applicable to the grinding and pulverizing of a wide variety of products from the process industries and the manufacturer is in a position to make test grind-

ings on special applications in their testing laboratory.

The crushers are built in two sizes, 9 by 9 and 15 by 9 in., weighing 350 and 750 lb. respectively. Horsepower requirements vary from one to ten, depending on the material being ground and the speed of the mill. The rotor consists of a main shaft of alloy steel, cast steel end discs and manganese steel rings or hammers. The shaft rotates on ball bearings which are mounted in dust tight self-aligning pillow blocks. The fineness of the ground product depends upon the screen openings, the screen plates fitting in grooves in the lower side housings. The round back part of the upper frame is protected by a renewable liner.

MASON-NEILAN REGULATOR CO., of Boston, Mass., has put into effect a new field demonstration service, for the benefit of engineers' industries where instrumentation and control are major problems. The new service unit, a specially designed truck, completely equipped with up-to-the-minute reducing valves and control instruments, is making a nation-wide tour, giving demonstrations of modern control in important chemical plants, paper mills, refineries, process and power plants.

Starting Unit for Gas and Diesel Engines

FOR STARTING gas and Diesel engines, a new fast-working single-stage air compressor capable of filling a tank of 6 cu. ft. capacity up to 200 lb. pressure in 5 min. or up to 250 lb. in 9½ min. is now offered by The Cooper-Bessemer Corp., Mt. Vernon, Ohio. This single-stage unit, to be known as the GX3A, runs on either gas or gasoline, is a simple, self-contained combination engine and compressor, Ford parts being largely used, such as pistons, piston rings, connecting rods, connecting-rod bearings, engine valves, and the like.

Power and compressor cylinders, cast in one piece, are water-jacketed, the power-cylinder head, which is a separate casting of the automotive type, being water-cooled. A Ford Model B gasoline carburetor and an adjustable gas mixing valve are furnished as standard equipment, also a rotary-type magneto with impulse coupling for hand starting.

Where gas is the fuel, it is possible to start the engine on gas; but the recommended procedure is to start on gasoline, then switch to gas, a 1-gal. gasoline tank being mounted over the compressor and connected to the carburetor. Splash lubrication is automatically provided for all parts, with oil reservoirs to feed lubricant to the main bearings, valve tappets, camshaft bearings, governors, and magneto drive.

LINK-BELT CO., Chicago, Ill., announces development of a new line of bearing units to be known as Link-Belt Shafer Self-Aligning Roller Bearing, Series 400. They are available for pillow blocks, flange bearings, hangers and take-ups. The alignment is provided by two lines of concave rollers bearing on a convex central sleeve and on convex outer races, set at an angle to the shaft axis so that the bearing can carry radial and thrust loads. The sleeve is free to deflect for a shaft temporarily misaligned yet the rollers will still travel in a true path on the sleeve and race surfaces. Dimensions, loads and other data are given in a new book No. 1494.

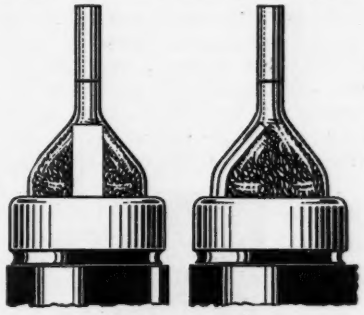
Bolts With Self-Centering Heads

ANNOUNCEMENT of the introduction of a new line of machine screws and stove bolts with the Phillips recessed, self-centering head, which has also been applied to wood screws and sheet metal screws, has just been made by the

American Screw Co. of Providence, R. I. This head has a tapered cross-shaped recess which fits a tapered driver and takes the place of the slot in the conventional screw. It is said that this design enables faster driving with less effort, provides better holding power, better appearance, reduced spoilage, fewer accidents and enables the screw driver, without other support, to hold the screw in a horizontal position.

Ellison Vision Panel

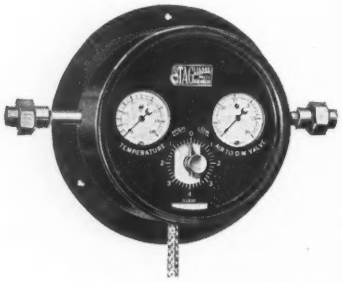
VISIBILITY of the solutions in the absorption chambers of the Orsat type of gas analyzers using fibrous material for surface absorption is improved by the provision of a vision panel developed by the Ellison Draft Gage Co. It is made of opal glass and is placed in the front



of the chambers with a space between the panel and the chamber wall for solution passage, as may be observed from the front and side views shown here. With the white background, close to the wall of the chamber, the solutions are easily visible even at a distance of several feet.

New Controller

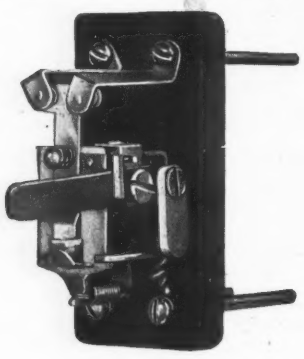
KNOWN AS the TAG number 40 controller, a new instrument, suited to the majority of automatic control applications, has been recently put on the market by the C. J. Tagliabue Mfg. Co., Brooklyn, N.Y. The principle of control is basically the TAG movement which has been redesigned for compactness in such a fashion that the few simple parts are accessible with exceptional ease. Tube systems can be interchanged with facility.



A spring lever designed to eliminate all motion multiplies the movement of a capsular spring for sensitive yet positive control. The smallest change in temperature is transmitted positively and with precision to the TAG Ball Air Valve which in turn resets the rate-of-flow through the diaphragm actuated control valve. In the TAG number 40 controller the sensitiveness is high and the accuracy is permanent. Indicating and Non-Indicating types in nine convenient temperature ranges and three pressure ranges are available in this new controller.

Mechanical Latch Manual Reset Relay

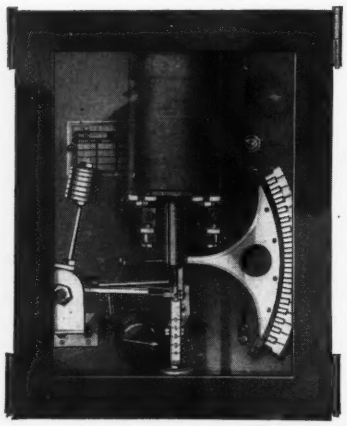
IT IS FREQUENTLY necessary on signal circuits to use some scheme whereby the operator may disconnect the signal and yet have the circuit returned to normal, when the need for the signal has passed, without further attention from the operator. Struthers Dunn, Inc., relay specialtists of Philadelphia, have developed a mechanical latch, manual reset relay for this service.



This relay operates as follows: it is provided with back contacts so that normally when the coil is energized, the contacts are open. Failure of power causes the relay contacts to close, energizing the alarm circuit. Operation of the reset lever disconnects the alarm circuit by latching the contacts open. When power is restored, the relay armature picks up and locks the contacts open electrically, at the same time allowing the reset lever to return to its original position.

Rocking Contact Voltage Adjuster

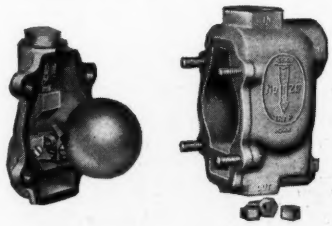
ALLIS-CHALMERS MFG. Co. announces its new "VI" Voltage Adjuster to meet the increasing demand for a reliable moderate cost voltage control unit for small alternators. It can be applied to a.c. generators, varying in size from 5 kv-a. at 360 r.p.m. through intermediate kv-a. and speed ratings up to 250 kv-a. at 3600 r.p.m., where voltage regulator requirements are not too exacting. Its general field of application covers various industrial and municipal installations, private and public institutions, apartment buildings, hotels, etc.



This new type of voltage adjuster is small in size and does not require much more space than the average graphic instrument. Its dimensions are 8⅞ in. wide, 11 in. high, and 9⅜ in. deep. It embodies the "Rocking Contact" design of the more expensive regulators, although it uses a solenoid operator in place of a torque motor, and uses an air dashpot in place of magnetic dampening. The unit is totally enclosed, pleasing in appearance, and will harmonize well with other instruments when mounted on a switchboard. It is adaptable to either surface mounting on the face of a switchboard or to bracket installation at either end of the switchboard.

New Steam Trap

AMERICAN DISTRICT STEAM CO., North Tonawanda, N. Y., is placing on the market a new steam trap which is a combination float and thermostatic type. The entire working mechanism is mounted on the cover, with all piping connections on the body. The cover and working mechanism may be removed for inspection and cleaning without disturbing the piping connections. Other outstanding features are, reversible valve and seat made of stainless alloy steel.



The ADSCO vertical steam trap is a continuous flow type. A deep water seal prevents loss of steam. A limit stop on the float lever prevents the elevation of the float beyond normal.

This trap is furnished in six capacities at given pressures. Two of the models are arranged for either vertical or 90 deg. inlet connections, while the third is provided for horizontal inlet and outlet connections from either side.

The smallest trap, weighing a little more than five pounds, is well adapted for installation with concealed and indirect radiation.

INSULCRETE is the name given to a hydraulic insulating refractory cement to take the place of fire brick and insulation combined, that has been developed by the Quigley Co., Inc., of New York City. It is designed for pouring furnace linings, doors, floors, covers and special shapes and is stated to have a light cellular structure with low heat storage, low permeability, high heat resistance, load capacity and resistance to thermal shocks, little shrinkage from casting to working temperatures, and quick

setting—in 12 to 24 hr. from the time of pouring.

Results claimed from these qualities are increased output and saving of fuel due to low heat absorption, rapid rise to working temperature, cooler furnace rooms and reduction of noise. Because of the plastic form it gives air and gas tight linings for furnaces and has a low cost of installation.

Oscar Junggren

OSCAR JUNGGREN, who was associated with the development of many of the most important advances in the design of large steam turbines and who until recently was design engineer of the General Electric Co.'s turbine department, died Tuesday evening, Sept. 24, at his home in Schenectady, N. Y., following an illness of about 14 mo.

Mr. Junggren was born in Landskrono, Sweden, January 10, 1865. He attended the engineering college of Malmo in that country, graduating in 1885 from the mechanical engineering course. Coming to this country, he was first

employed by the Edison Electric Co. in New York City in 1889. In 1891, he became associated with the General Electric Co. In 1907, he was appointed design engineer, and in 1922, consulting engineer of the turbine department.

In 1931, he received a Charles A. Coffin Award, having been cited for his work as a creator and designer of large turbine units and particularly for his invention of the steeple compound turbine. He was an associate Edison Pioneer, a member of the American Society of Mechanical Engineers, the American Sons and Daughters of Sweden, and of numerous other organizations.

Navy Lets Submarine Contracts

CONTRACTS for the building of submarines Nos. 182 to 187 were placed by the Navy Department on September 28, 1935. Two of these submarines will be constructed at the United States Navy Yard at Portsmouth, Maine, and one at the Mare Island, California Navy Yard. The other three will be built at the Ship Yards of the Electric Boat Co., Groton, Conn.

Machinery contracts, including the Diesel engines and electrical equipment for the six vessels have been placed with two companies. The Winton Engine Corp., Cleveland, O., will furnish the machinery for three submarines and the Hooven-Owen-Rentschler Co., Hamilton, O., will furnish the equipment for three submarines.

The electrical equipment for all six submarines will be built by the Elliott Co., Pittsburgh, Pa., at its works in Ridgway, Pa. The total contract with the Winton Engine Co., is $2,288,145 and the contract with Hooven-Owen-Rentschler is $2,447,232. The Elliott Co.'s share in both contracts is considerably over $1,000,000.

Including this contract the Elliott Co. will have furnished the electrical machinery for 12 of the last 16 submarines let under the new submarine building program covering the past 2 yr.

A.S.M.E. Annual Meeting Program

FOR THE ANNUAL MEETING of the American Society of Mechanical Engineers to be held in the Engineering Building, New York City, on December 2 to 6, an unusually full program of technical papers has been arranged covering the entire field of mechanical engineering in sessions devoted to the following general topics: Machine shops, psychology, railroads, hydraulics, sugar, mechanical springs, power, processes, occupational diseases, metal cutting, petroleum, iron and steel, textiles, compensation laws, locomotives, boiler furnaces, fan test code, fuels, costs, applied mechanics, aeronautics, radiant heat, wood industries, oil and gas power, and boiler feedwater.

Papers on the program of particular interest to power plant engineers are:

Cause and Prevention of Turbine Blade Deposits by F. C. Straub.

An Airfoil Type Propeller Blower for Ventilating Electric Machine by C. E. Peck and M. D. Ross.

Steam Turbine Testing (A proposal to use Impact Pressures and Temperatures).

The Flow Characteristics of Variable Speed Reaction Turbines by A. Egli.

The Viscosity of Water and Superheated Steam by G. A. Hawkins, H. Solberg and A. A. Potter.

Factors in the Selection of Coal for Underfeed Stokers by Committee on Fuels. Engineers representing Appalachian Coals, Inc., R. L. Rowan, L. A. Shipman, T. H. Queer, K. J. Kasper, O. O. Mallers and J. E. Tobey.

Symposium on Zoned and Metered Air Control for Underfeed Stokers by H. E. Macomber, A. S. Griswold and J. N. Landis.

The Life of Various Types of Furnace Bottoms for Tapping Ash in the Molten State by Rolfe Shellenberger.

Water Cooled Stokers by J. S. Bennett and C. J. Herbeck.

Electrostatic Precipitators for Stoker Fired Boilers by C. W. Hedberg.

Industrial Production Costs by C. H. Knapp.

Power Distribution Costs by Morris L. Cooke.

Film Lubrication Theory and Engine Bearing Design by E. S. Dennison.

Ignition and Combustion of Diesel Fuels by G. D. Boerlage and J. J. Broeze.

Oil Engine Electric Generating Station Operating Costs by Geo. C. Eaton.

1934 Cost Data Report.

The Use of Solubility Data to Control the Deposition of Sodium Sulphate or its Complex Salts in Boiler Water by W. C. Schroeder, A. A. Berk and E. Partridge.

Estimation of Dissolved Solids in Boiler Water by Density Readings by J. A. Holmes and J. K. Rummel.

Suspended Solids in Foaming and Priming of Boiler Water by Prof. C. W. Foulk.

Effect of Solutions on Endurance of Low Carbon Steel Under Repeated Torsion at 482 deg. F. (250 deg. C.) by W. C. Schroeder and Everett P. Partridge.

Embrittlement of Boiler Steel by Caustic Soda by G. H. Wagner and J. R. Wall.

Study of Effect of Concentrated Sodium Hydroxide on Boiler Steel Under Tension by A. S. Perry.

News From the Field

ANNOUNCEMENT has been made by T. M. Girdler, chairman of the board of the Republic Steel Corp., that the general offices of the corporation will be consolidated in Cleveland, O., the date set being January 1. This will bring together the general offices now located in Youngstown, the advertising department now located in Massillon and the executive offices now in the Union Trust Building, Cleveland, O.

CHEYENNE AGENCY, South Dakota, is building a new central heating plant for its Indian School and Hospital. The project calls for remodeling of present building. Two new 150-hp. H.r.t. boilers, stoker fired; vacuum pumps and boiler feed pumps are to be installed. Other items include a 125-ft. brick stack and about 2000 ft. of distribution main. Fund of $45,000 is being obtained from P. W. A.

A CONFERENCE of managers of municipal power plants will be held in Kansas City, Mo., and Kansas, on November 7 and 8 which will be attended by representatives of the Rural Electrification Administration. The primary purpose of this conference is to bring together municipal plant managers and operators for discussion of their common technical and operating problems but attention will also be paid to the possibilities of collaboration between plants and REA. Among the topics which will be on the program for discussion are rates to rural customers, costs of line extensions and coöperation with government agencies.

JOHN PRIMROSE has been elected to the office of vice chairman of the board of the Foster Wheeler Corp. following the resignation of Pell W. Foster, who will continue as a director. In 1901 Mr. Primrose became chief engineer of the Power Specialty Co., and subsequently vice president in charge of oil refinery activities. When the Foster Wheeler Corp. was formed, Mr. Primrose was elected a vice president, which office he has held to the present.

TWO NEW appointments are announced by The Paul B. Huyette Co., Inc., of Philadelphia, Pa. Charles T. Kemp, Jr., at Preston St. and Guilford Ave., Baltimore, Md., and Frank W. Hoyt, Scranton Life Building, Scranton, Pa., as district representatives in their respective territories of P. B. H. boiler appliances, Hays Corporation instruments and Reliance Gauge Column Co. water columns.

THE BABCOCK & WILCOX Co. has opened a sales office in the Railway Exchange Building, St. Louis, Mo., with F. C. Brandt, formerly of the Chicago office of this company in charge.

ANNOUNCEMENT has been made by the General Electric Co. that during the first nine months of 1935, sales billed amounted to $149,173,275.12, compared with $121,735,122.98 during the corresponding period last year.

ANNOUNCEMENT is made by Felt Products Mfg. Co. of the appointment of Joseph M. Bandish as Director of Sales of the metallic packing division of that firm. Mr. Bandish's new offices will be located in the Felt Products Building at 1508 Carroll Ave., Chicago, Ill.

BYLLESBY ENGINEERING & MANAGEMENT CORP., Chicago, Ill., the stock of which has heretofore been owned by the Standard Gas & Electric Co., has been sold (without profit to the S. G. & E. Co.) to the operating companies of the system and will be operated in the future as a mutual service company. This move was made to carry out the spirit of the recently enacted Federal Public Utility Act of 1935, various state legislation, and the decisions of certain state regulatory commissions.

At a meeting of the stockholders of the corporation the following persons were elected to the board of directors: J. F. Owens, president of Oklahoma Gas & Elec. Co.; Frank R. Phillips, president of the Philadelphia Co.; Robert F. Pack, president of Northern States Power Co.; T. B. Wilson, president of Louisville Gas & Elec. Co.; J. P. Pulliam, president of Wisconsin Public Service Corp.; W. F. Raber, president of San Diego Consolidated Gas & Elec. Co.; C. M. Brewer, president of Mountain States Power Co. and The California-Oregon Power Co.; and W. N. Clark, president of Southern Colorado Power Co.

CHANGES announced by J. J. Donovan, manager of the Air Conditioning Department, General Electric Co., are as follows, due to consolidation of all divisions of the department at Bloomfield, N. J.: E. J. Opal becomes manager of the Gas Furnace and Air Circulator division; E. B. Skiddell is appointed assistant to the manager of the Air Condition department; A. C. Roy, Advertising and Sales Promotion Manager will serve as chairman of the sales committee; R. U. Berry will be in charge of special applications; H. E. Perkins becomes a member of the product committee and chairman of the manufacturing committee. Divisions of the company in all eastern cities were moved to Bloomfield in July and recently 50 members of the department were transferred from Schenectady to complete the consolidation.

FOSTER WHEELER CORP. announces the appointment of John F. Glenn to the New York office sales division. Mr. Glenn has been associated with the Foster Wheeler sales activities for the past 2 yr. and has previously been connected with other boiler builders. During the world war he was connected with the War Industries Board at Washington and in charge of priority applications for power house equipment.

ELGIN SOFTENER CORP., Elgin, Ill., has appointed the Kent-Ervin Engineering Co., 732 Builders Exchange Building, Minneapolis, as agent to handle its line of boiler water conditioning and control equipment. The Kent-Ervin organization will serve Minnesota, northwest Wisconsin, and North and South Dakota.

V. L. SANDERSON has been appointed sales representative for the American District Steam Co. in Philadelphia and the State of Delaware with headquarters at 1108 Otis Building, Philadelphia, Pa.

THE BROWN INSTRUMENT Co. has announced, through its Chicago District office, the opening of an office in Milwaukee, Wis., at 325 W. North Ave., with I. K. Farley as sales engineer. This office will also handle the products of Minneapolis-Honeywell Regulator Co. in keeping with the recent consolidation of these two companies.

DON S. WALKER has been appointed District Manager in the Philadelphia office of Combustion Engineering Co., Inc., and will be responsible for sales in both the Philadelphia and Washington territories.

THE KENNEDY VALVE MFG. Co. announces the appointment of William Godbey as its representative in Kansas, Nebraska, Western Missouri, and Southwest Iowa. Mr. Godbey will have headquarters in Kansas City, Mo.

T. FRANK WEBSTER of the Link Belt Philadelphia office has been appointed resident manager at Boston, succeeding Horace Goldstein who goes to engineering sales work in Philadelphia.

INDUSTRIAL Lubrication Council, Inc., 51 E. 42nd St., New York City, has been established as a non-profit organization to furnish instruction by correspondence to the industrial user of lubricants. Increase in running speeds and bearing pressures, as well as changes in lubricants make it essential that lubrication be carefully engineered. Many oil companies have lubrication engineers but the trend of opinion seems to be toward the employment of independent lubrication engineers by the industrial plants. The objects of the Council are stated as: Advancement of the art of lubrication; to conduct education on the fundamentals and practice of machine lubrication; to assist in developing courses in lubrication engineering in trade schools and colleges; to provide articles and text books on the subject; to establish a clearing house for ideas and conduct conferences for the discussion of lubrication problems.

THE BABCOCK & WILCOX TUBE Co., Beaver Falls, Pa., has appointed R. P. Kilsby to the managership of its western sales territory with jurisdiction over all the districts covered by its offices located west of the Mississippi River and will make his headquarters at the Company's Chicago Office in the Marquette Building.

JAMES L. CAREY, paper mill architect and engineer, Chicago, Ill., died suddenly Monday, September 9, at his summer home near Kenosha, Wis. Mr. Carey was born May 17, 1864, at Menasha, Wis. He was graduated from the University of Wisconsin in the class of 1888 with the degree of mechanical engineer. Upon leaving the university he was employed by the Black-Clawson Co., Hamilton, O., paper machinery builders. Among the mills designed by Mr. Carey during the period from 1907 until the time of his death, are the following: American Coating Mills, Elkhart, Ind.; Container Corporation of America, Ogden mill, Chicago and Cincinnati mill, Cincinnati, O.; Consolidated Paper Co., Aurora, Ill.; Hummel & Downing Co., Milwaukee, Wis.; Michigan Carton Co., Battle Creek, Mich.; North Star Strawboard Mills, Quincy, Ill.; Bemis Bros. Bag Co., Peoria, Ill.; Central Fibre Products Co., Hutchinson, Kan., and Pioneer-Flintkote Co., Los Angeles, Cal. Numbered among Mr. Carey's foreign clients were the Australian Paper Manufacturers, Ltd., Melbourne and Sydney, Australia; the Chin Hua Card Board & Paper Manufacturing Co., Tientsin, China, and the Alliance Box Co., Warrington, England.

For the Engineer's Library

SEWAGE AND SLUDGE pumps are covered in Bulletin 206 just issued by the Lawrence Machine & Pump Corp., 371 Market St., Lawrence, Mass.

THE MANHATTAN RUBBER MFG. Division of Raybestos-Manhattan, Inc., Passaic, N. J., has issued a bulletin on the Condor Compensated Belt which is a low tension rubber belt designed to give equal stress on all plies of the belt as it is flexed around the pulley.

O. C. KECKLEY Co., Chicago, Ill., is distributing a new catalog which describes steam and liquid control equipment manufactured by this company. The catalog is designated as No. 35 and is well illustrated with halftones, wash drawings and line drawings to make clear the operation of the various products of the company.

ARC WELDING Electrodes and Accessories as made by The Lincoln Electric Co., Cleveland, Ohio, are fully described and illustrated in a new 36-page booklet. The "shielded arc" process is described, properties of weld metals given, methods of welding illustrated, various electrodes with their properties and uses given, also electrode holders and accessories, protective devices are shown, repair parts are listed and "shield arc" welders illustrated.

IN A NEW 48-page book on Johns-Manville Industrial Products, are described and illustrated the application and uses of insulating materials, refractories, roofings and transite in its various forms, as well as other products. Construction photographs, drawings, tables and charts show proper methods for pipe and boiler covering, furnaces, roofs, floors and conduits. Copies may be had from Johns-Manville, 22 E. 40th St., New York City.

KEEPING FLOORS, Roofs, Walls and Foundations in Repair is the subject of a 24-page, illustrated booklet issued by the Stonhard Co., covering concrete and wood floors, waterproofing of roofs and masonry. The title is "Over the Rough Spots" and it can be had by sending a request to the Company at 401 N. Broad St., Philadelphia, Pa.

HARNISCHFEGER CORP. of Milwaukee covers, in a new 24-page bulletin, HW-4, "Weld It Well," the complete line of P&H-Hansen Arc Welders from 50 to 800-amp. units as well as welding fixtures and accessories.

NORTON Co., Worcester, Mass., is distributing a new bulletin dealing with Norton Porous Mediums in both plate and tube form as used in sewage treatment systems.

RESEARCH PUTS the Diatom to Work. A diatom is a tiny plant which some 50,000 centuries ago existed in number to form from their remains deposits of diatomaceous earth. This is so light that it was called by the ancients "swimming brick" and has been put to work as Celite by Johns-Manville, which gives in an interesting booklet the history of diatoms and explains how the deposit is used for insulation, filtering, mineral filler and in concrete mixtures. The booklet may be had from Johns-Manville (FA-7A), 22 E. 40th St., New York City.

THE FOXBORO Co., Foxboro, Mass., has published a new 20-page bulletin, No. 202, covering its complete line of potentiometer and resistance thermometer controllers, including the new Type H drive unit which lowers the investment cost. The reader will find in this bulletin instruments to handle practically every problem of industrial high temperature control.

TWO INTERESTING catalogs were received from Wm. Bros Boiler & Mfg. Co., Minneapolis, Minn. One describes and illustrates the construction and action of Bros Super-Spred Stoker with capacity of 6000-lb. an hr.; the other is devoted to Evolution of a Modern Boiler and the details, settings and performance of Bros "Modern" boilers.

ILLUSTRATED descriptive leaflet on its flow meters is issued by The Brown Instrument Co., Philadelphia, Pa., showing the mechanical, electric and area types of body and emphasizing the importance of looking into power costs.

AUTOMATIC ARC WELDING by the Electronic Tornado, is the title of a 40 page booklet issued by The Lincoln Electric Co., Cleveland, Ohio, in which the process is described, quality of welds shown and the methods of making various types of welds, time taken and cost of the process given. Use of the method in various industries is illustrated and the equipment for the industry is listed in detail. Handsomely printed and illustrated, the book is an interesting resumé of the art.

FACTS ABOUT Built-up Roofs are given by Johns-Manville, 22 E. 40th St., New York City, in a 24-page brochure, which discusses what a built-up roof is, requirements for a good roof, materials and methods used and points requiring special attention such as flashings, insulation and prevention of rot and corrosion. Drawings show details of construction and tables give the amounts of materials required per 100 sq. ft.

ALDRICH PUMP Co., Allentown, Pa., shows in Data Leaflet 25 its triplex power pumps for the oil industry and in Data 59, 60 and 60-A, its power pumps, centrifugal pumps and hydraulic machinery of various types.

POTENTIALITIES AND POSSIBILITIES of the Diesel engine in rail transportation is discussed in Research Bulletin No. 49 recently issued by the Engineering Experiment Station of Purdue University, Lafayette, Ind. This booklet prepared by A. I. Lipetz, consulting engineer of the American Locomotive Co. and non-resident professor of railway engineering at Purdue, and is a summary of lectures delivered there during March, 1935.

MARSHALL HEATER Co., Dayton, Ohio, has just issued a new bulletin on the Marco Type E-V-O hot water heater, describing its construction in detail and giving information on installation.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., required by the Act of Congress of March 3, 1933, of Power Plant Engineering, published monthly at Chicago, Illinois, for October 1, 1935.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Arthur L. Rice, who, having been duly sworn according to law, deposes and says that he is the Editor of the Power Plant Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.

Editor, Arthur L. Rice, Chicago, Ill.

Managing Editor, R. E. Turner, Chicago, Ill.

Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the name and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co.
E. R. Shaw, Chicago, Ill.
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K. L. Rice, Chicago, Ill.
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3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the twelve months preceding the date shown above is ..... (This information is required from daily publications only.)

TECHNICAL PUBLISHING CO.
ARTHUR L. RICE,
Editor.

Sworn to and subscribed before me this 27th day of September, 1935.

[Seal.] W. A. HERBSTER,
Notary Public.

(My commission expires June 19, 1936.)

Power Plant Construction News

Ariz., Flagstaff—Arizona Power Co., Prescott, Ariz., plans new transmission line from hydroelectric generating plant on Fossil Creek to Flagstaff, about 40 miles, for furnishing power to Flagstaff Electric Light Co., which will build new power substation. Cost about $75,000.

Calif., Palo Alto—Board of City Trustees has secured grant of $218,100 from PWA, to make gross fund of $727,000 for new municipal electric light and power plant, and transmission lines. Proposed to begin work at early date. City engineering department is in charge. Lester S. Ready is consulting engineer.

Calif., Richmond—Standard Oil Co. of California, Financial Center Building, San Francisco, Calif., has authorized plans for new steam-operated electric power plant at oil refinery at Richmond on San Francisco Bay. Cost close to $1,000,000, with equipment. Stone & Webster Engineering Corporation, 49 Federal Street, Boston, Mass., is consulting engineer.

Conn., Fairfield—McKesson & Robbins, Inc., Grasmere Avenue, plans installation of electric power equipment in new three-story addition to drug and pharmaceutical manufacturing plant. Cost close to $80,000. Work will soon begin. Albert Kahn, Inc., New Center Building, Detroit, Mich., is architect and engineer.

Fla., Deland—City Council plans new municipal electric light and power plant, and electrical distributing system, including street-lighting system. Fund of $444,000 has been secured through PWA. Proposed to begin work soon.

Fla., Miami—Department of Public Service, William Sydow, director, plans extensions and improvements in municipal incinerator plant, including installation of new steam turbine unit and accessories, boiler, pumping machinery and other equipment. Fund of $70,900 has been secured for project through Federal aid. Proposed to begin work soon.

Ga., Atlanta—Atlanta Gas Light Co., plans extensions and improvements in artificial gas plant, including installation of additional equipment for increased capacity. Cost over $250,000. Financing is being arranged. Company engineering department is in charge.

Ind., Bloomington—Board of Trustees, Indiana University, has plans under way for extensions and improvements in power plant at institution, including installation of new equipment. Cost about $125,000. Fund has been secured. Charles R. Ammerman, Century Building, Indianapolis, is consulting engineer.

Ind., Portland — Acme Electric Co., Portland, plans hydroelectric power development on Salamonie River, Huntington and Wabash Counties, Ind., including power dam, generating station, power and switching substations, and about 9 miles of transmission lines. Proposed station will have initial capacity of about 5000 kw. Cost over $500,000. Application has been made for Federal permission.

Iowa, Exira—Common Council is securing fund of $75,000 through PWA for new municipal electric light and power plant, and will have plans completed at early date, when bids will be asked. H. L. Cory, Baum Building, Omaha, Neb., is consulting engineer.

Iowa, Fairfield—City Council has authorized plans for new power plant in conjunction with municipal waterworks station, using Diesel engine-generating units and accessories, fuel oil tank system, etc. Cost about $100,000. Federal Engineering Co., Central Office Building, Davenport, Iowa, is consulting engineer.

Kan., Mankato — Common Council has plans nearing completion for new municipal electric light and power plant, and electrical distribution system. Fund of $111,000 is being arranged through Federal aid. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

La., Baton Rouge — Baton Rouge Coca Cola Bottling Co. plans installation of electric power equipment, conveyors, etc., in new two-story mechanical bottling works. Cost about $40,000. Proposed to begin work soon. Norman V. Riviere, Kings Hotel Building, Baton Rouge, is architect.

La., Ponchatoula—Common Council plans new municipal electric light and power plant, and cold storage and refrigerating plant. Cost about $125,000. Financing will be arranged through Federal aid. W. R. Haight, mayor, is active in project.

Mass., Worcester—Board of Directors, City Hospital, has preliminary plans under way for new addition to power house at institution, including installation of new equipment. Estimates of cost will soon be made. Edward J. Tucker, City Hospital, is engineer.

Mich., Dearborn—Ford Motor Co., Dearborn, plans installation of electric power equipment in connection with extensions and improvements in paper mill at Dearborn, used for production of paper-board products for automobile service. Cost over $60,000. Giffels & Vallet, Inc., Marquette Building, Detroit, Mich., is consulting engineer.

Mich., Detroit—Shatterproof Glass Co., 151 South Waterman Avenue, plans installation of electric power equipment in connection with proposed rebuilding of portion of safety sheet glass manufacturing plant, recently destroyed by fire. Loss over $150,000.

Mich., Pontiac—Baldwin Rubber Co., plans installation of electric power equipment in two new one-story additions to rubber mill, 100x142 ft., and 20x180 ft., respectively. Cost over $75,000. L. J. Heenan, Pontiac, is architect.

Mich., St. Louis—Michigan Chemical Corporation is the name of company recently organized to construct and operate a plant here, and not Michigan Alkali & Chemical Corporation, as incorrectly noted in these columns appearing in the September issue. Project will be carried out as previously announced. Company is chartered with capital of $400,000, and represented by John L. Giles, Manistee, Mich.

Minn., Eveleth—City Council has secured fund of $886,000 through PWA for new municipal electric light and power plant, electrical distributing lines and steam distribution lines. Work will proceed at early date. H. D. Sholund is city engineer, in charge.

Minn., Murdock — Village Council plans call for bids early in November for equipment for municipal water system, including deep-well centrifugal pumping machinery and accessories, 50,000-gal. elevated tank and tower, hydrants, pipe lines, etc. Fund of $30,000 available. Ealy G. Briggs, 1957 University Avenue, St. Paul, Minn., is consulting engineer.

Minn., Owatonna—State Department of Administration and Finance, State Capitol Building, St. Paul, Carl R. Erickson, purchase commissioner, has plans under way for new addition to power house at State school at Owatonna. Cost about $58,000, with equipment. Larson & McLaren, Roanoke Building, Minneapolis, Minn., are consulting engineers.

Miss., Duck Hill—Common Council has plans nearing completion and soon takes bids for equipment for waterworks extensions and improvements, including pumping machinery and auxiliaries, 50,000-gal. elevated steel tank and tower, pipe lines, etc. Fund of $54,000 has been arranged. John M. Gilfillan & Associates, 617 North Tenth Street, Birmingham, Ala., are consulting engineers.

Mo., Springfield—Producers' Creamery Co., plans installation of electric power equipment in new two-story addition to milk processing and distributing plant. New cold storage system will be installed. Cost about $175,000.

Mont., Great Falls — Great Falls Breweries, Inc., plans installation of power equipment in new addition to brewery, for increased capacity in malt division. Cost over $50,000, including machinery. P. W. Kuschel is general manager.

N. J., Camden—Board of City Commissioners has adopted a resolution providing for new municipal electric light and power plant, estimated to cost $10,000,000, and project will be voted on by citizens at November general election. Financing will be arranged through Federal aid.

N. Y., Buffalo—Niagara, Lockport & Ontario Power Co., Electric Building, plans extensions in transmission and distributing lines in portions of Allegany, Cattaraugus, Genesee, Monroe, Ontario and other neighboring counties for rural electrification, totaling about 1600 miles in all. Project will include power substation and service facilities. Cost over $1,500,000. Permission has been secured.

N. Y., Plattsburg—City Council has plans nearing completion for new municipal electric light and power plant, and electrical distribution system. Fund of $550,000 has been secured through Federal aid for project. Proposed to begin work soon. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

N. Y., Rochester—Eastman Kodak Co., Kodak Park, plans installation of electric power equipment in new addition to camera and film-manufacturing plant. Cost about $400,000.

N. D., Crosby — Common Council plans new municipal electric light and power plant. Financing has been arranged through Federal aid. Cost about $90,000, including electrical distributing lines. T. R. Atkinson, Court House, Bismarck, N. D., is consulting engineer.

Texas, Houston — Kraft-Phenix Cheese Co., 400 North Rush Street, Chicago, Ill., plans installation of electric power equipment in new branch plant on 27-acre tract of land in vicinity of Kessler Street and White Oak Drive, Houston. Cost close to $100,000.

Wis., Racine—Board of County Commissioners plans new steam power plant at Sunny Rest County Sanatorium, for central heating service at institution. Fund of $34,500 has been authorized. Proposed to begin work soon. County engineer will be in charge.